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THE SAVOYARDE—THE BELL OF THE CHURCH OF THE SACRED HEART, PARIS.

WE have already given an account of the accident to a locomotive which, having escaped from the Paris-Montparnasse Station, had to be taken through the streets of the capital to the Anciens Etablissements Cail, for repair. The carriage of such a mass (35 tons) over ordinary roadways is rare enough to attract some attention; yet, owing to the route followed, it certainly offered fewer difficulties than were met with in carrying the famous bell, the Savoyarde, to the Church of the Sacred Heart in Paris. The weight of this bell, it is true, reaches scarcely half that of the locomotive, but, while the latter had only to descend wide avenues to reach its destination, the bell had to be taken through relatively narrow streets up to the summit of Montmartre, that is to say, to the culminating point of Paris.

As a bell weighing more than eighteen tons is an exceedingly rare piece, whose manufacture presents somewhat curious features, we think a few data, not only as to the carriage of this bell, but also as to the processes used in its manufacture, will be read with interest.

The Savoyarde, thus called because it is the product of a subscription got up by the Savoyards in the diocese of Annecy (Haute Savoie) is a magnificent piece of bronze of a single casting weighing 18,835 kilogrammes. Its largest diameter is 3·03 meters and its height, exclusive of the ears, is 3·06 meters. Its clapper, which is of forged iron, weighs 850 kilogrammes, and its yoke, by which it is to be suspended, 7,380 kilogrammes; so that the whole weighs a little over twenty-seven tons.

FIG. 1.—UNLOADING THE SAVOYARDE AT THE PARIS-LA CHAPELLE STATION.

As may be conceived, it requires a special belfry to receive such a bell, not only on account of the latter's immense weight, but especially to resist the forces that will be brought into play when it is desired to ring a full peal. This maneuver, in fact, will give rise to horizontal components prejudicial to the stability of the edifice. Moreover, the strong vibrations that will be transmitted to the supports might, in the long run, end in disintegrating the masonry. It will doubtless be possible, through special arrangements, to attenuate these destructive effects and even to render them harmless, but this is a study still to be made, since the belfry provided for by the late M. Abadie, the author of the project of the Church of the Sacred Heart, was not designed to receive a bell of so large a size.

It was without occupying themselves with the arrangement originally planned for the belfry that the Savoyards conceived the idea of providing it with a bell larger than any as yet existing in France. Up to the present the largest bell of any French church has been that of Notre Dame, of Paris, which weighs 12,500 kilogrammes, nearly two-thirds of the weight of the Savoyarde. Now, the vibrations transmitted by this bell to the tower that supports it, when it is made to ring a full peal, are such that they have caused fear for the security of the edifice, and that it was long before it was dared to risk this maneuver. It was not until the framework belfry that supports it was restored by Viollet-le-Duc in 1860 that the bell was rung at full peal again.

According to the Messrs. Paccard, the founders of the Savoyarde, the method of suspension adopted for this bell will render the reactions upon the supports less dangerous at the moment when it is set in motion, and it will take eight men to ring a full peal instead of the twelve that are necessary at Notre Dame; but it will nevertheless be indispensable to take all the measures requisite against the dangers that the setting in motion of so large a mass may give rise to. It is to be hoped that the distinguished M. Rauline, the present architect of the Church of the Sacred Heart, will be able to overcome all difficulties.

Although from the view point of the art of the founder the Savoyarde is a very remarkable bell as regards its size, several old bells may be cited that are much larger. The invention of bells dates back to the remotest antiquity, and, according to Father Kircher, must be attributed to the Egyptians. On another hand, it is known that the use of them was familiar to the Chinese at least 2,000 years before our era. Yet it is only among the peoples of the extreme East that large bells appear to have been known in very remote times, and we remark the use of them no more among the Romans than among the Greeks. It is to Christianity that must be attributed the development of the use of bells, and especially the increase in their power. There is mentioned a bell of the eleventh century, that of St. Aignan, of Orleans, weighing 1,300 kilogrammes, which, for that epoch, was certainly more remarkable than the casting of a bell of 19,000 kilogrammes in our day. During the twelfth and thirteenth centuries, the art of the founder made very remarkable progress. In the course of the fourteenth century appeared the bell of the Cathedral of Paris, weighing 12,500 kilogrammes, that of Cologne, weighing 11,000 kilogrammes, that of St. Peter's at Rome, weighing 7,500 kilogrammes, etc.

At about the same epoch was cast the Cardailhac, of Toulouse, which, it is said, weighed 25,000 kilogrammes, and, in 1519, the famous bell of Strasbourg, the weight of which was 21,000 kilogrammes. Since then, still more colossal bells have been cast, if not in France, at least in foreign countries. Moscow possesses two bells, one of which weighs 65,000 and the other 67,000 kilogrammes, and a third, called Tzar Kolokol, or "Empress of Bells," that weighs nearly two hundred tons and the base of which is 7·5 meters in diameter. It was cast in 1734, but could not be taken from its mould till 1836, and since that epoch has rested simply upon a pedestal.

According to the Nouveau Journal Asiatique, the largest bell ever cast is doubtless the one that was possessed in the sixteenth century by the city of Rangoun, in Burmah, and the weight of which was, it is said, more than four hundred tons. But this figure, impossible to verify, must be accepted with caution. According to Abbot Brand, Nankin in the sixteenth century possessed a bell of 50,000 kilogrammes and another of 25,000, and the great bell of Pekin that serves to announce the hours weighs 60,000.

Finally, it is said that there are in India two huge bells still existing, that of the pagoda of Rangoun weighing more than 94,000 English pounds, and that of Mingoun more than 200,000.

As may be readily seen, such bells are not designed to be set in motion. They are simply struck with pieces of hard wood, which gives a feebler but softer tone than metallic clappers. Chinese bells, moreover, have a somewhat different form from ours, they being nearly cylindrical.

It cannot be said, then, that the Savoyarde is a bell of exceptional dimensions, and if it is really remarkable it is much less by its size than by the finish of its work and of the ornaments that embellish it and by the purity of the sound that it emits. Moreover, it is the first bell of its size that has not been cast at the foot of its belfry, but simply in an ordinary foundry

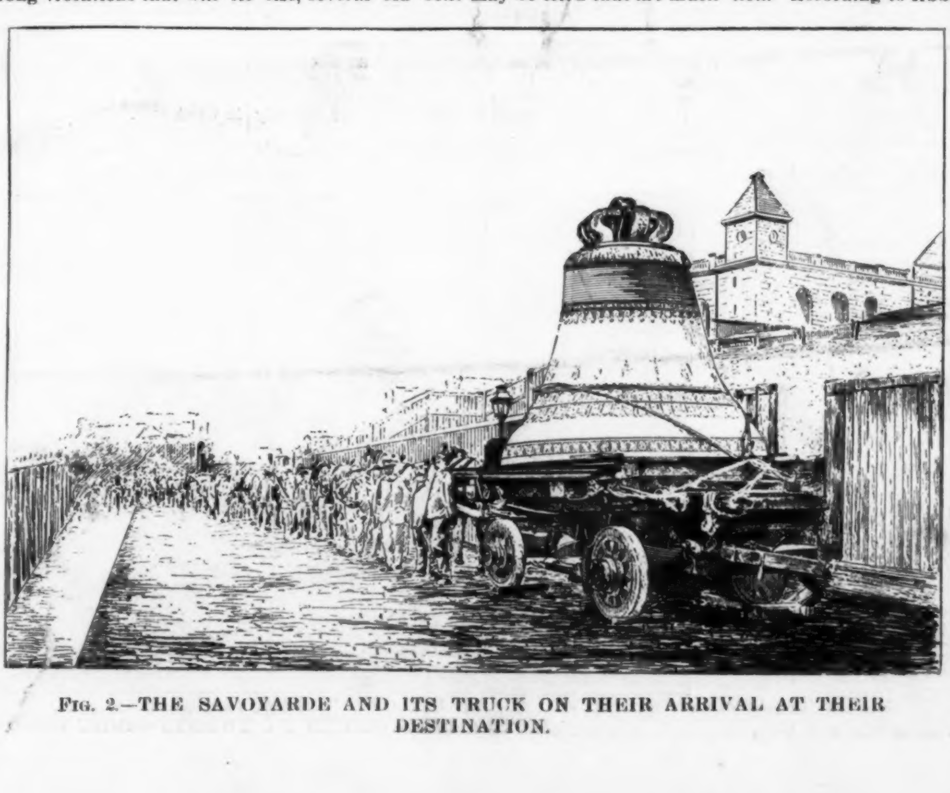


FIG. 2.—THE SAVOYARDE AND ITS TRUCK ON THEIR ARRIVAL AT THEIR DESTINATION.

and without the use of special installations. At the epoch at which the large bells just spoken of were cast it would have been impossible, in fact, in consequence of the want of proper ways of communication, to carry them to a great distance. The founders were obliged to cast them in situ, and this could only increase the difficulties of the work.

Since means of communication have been improved, founders have given up their itinerant foundries, and, in creating stationary ones in which a certain number of bells can be cast at once, have introduced new improvements into their art. So they are now able to furnish upon order bells that render such or such a sound fixed in advance. The Paccard Brothers especially have, in this respect, succeeded in obtaining a remarkable degree of accuracy, and the Savoyarde gives with perfection the grave counter do that had been specified before casting.

In order to understand how such a result can be obtained, it suffices to know that in bells of like form and composed of the same metal the number of vibrations

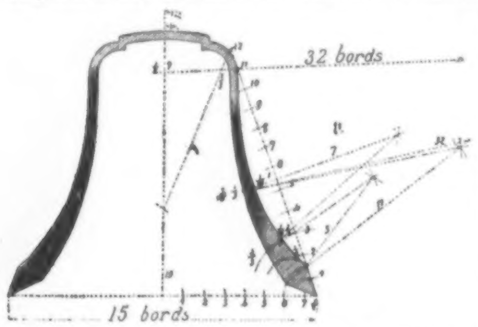


FIG. 3.—DIAGRAM OF A BELL OUTLINE.

is in inverse ratio of homologous dimensions, and, consequently, of the diameter, or, what amounts to the same thing, of the cubic root of the weight. Therefore, it may be well understood how, knowing a bell that furnishes a given note, that is to say, that produces a definite number of vibrations, it is possible to manufacture a like form, but producing a greater or less number of vibrations, that is to say, giving a higher or lower note. It is also due to this law that it is possible to construct series of bells or chimes possessing the various notes chosen in advance. For a chime forming a complete gamut the diameters of the bells vary in the same ratios as those expressing the numbers of vibrations corresponding to each note, that is to say, proportional to the following numbers:

	Do	Ri	Mi	Fa	Sol	La	Si	Do
	1	$\frac{9}{8}$	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{5}{3}$	$\frac{15}{8}$	2
Or	21	27	30	32	36	40	45	48

Every well made bell, moreover, gives, like the violin string [or the] organ pipe, according to its funda-

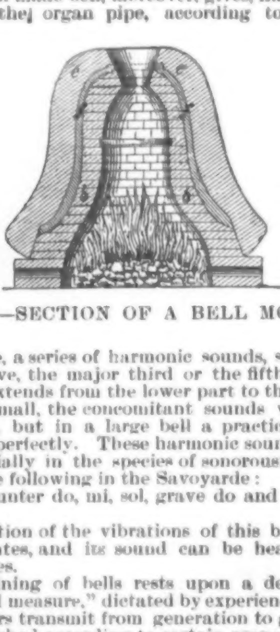


FIG. 4.—SECTION OF A BELL MOULD.

mental note, a series of harmonic sounds, such as the upper octave, the major third or the fifth, while the vibration extends from the lower part to the apex. If the bell is small, the concomitant sounds will not be perceptible, but in a large bell a practiced ear will seize them perfectly. These harmonic sounds, concurring essentially in the species of sonorousness of the bell, are the following in the Savoyarde:

Grave counter do, mi, sol, grave do and upper octave do.

The duration of the vibrations of this bell reaches seven minutes, and its sound can be heard at more than 18 miles.

The outlining of bells rests upon a definite base called "bell measure," dictated by experience and that bell founders transmit from generation to generation. It is established according to certain proportions that serve to regulate between them and to put in harmony the various parts of the bell. It is the rim, that is to say, the greatest thickness of the bell, that serves as an element for determining all the other dimensions.

FIG. 5.—MODEL OF THE EARS.

In the Savoyarde the rim thickness is a fifteenth of the great diameter, say 0·202 m.

There are several methods in use for the determination of the profile of bells, but the one most usually adopted, and the one according to which the Savoyarde was fashioned, consists in giving:

Fifteen rims to the large diameter.

Seven and one-half rims to the diameter of the crown.

Twelve rims to the line that joins the lower edge of the bell with the springing of the crown.

Thirty-two rims to the large radius serving to trace the external profile of the bell properly so called.

Fig. 3, in which all the lines of construction are figured in taking the dimensions of the rim as a unit, suffices to show exactly how the outlining can be effected. This outline is afterward transferred to the mould board, the dimensions of which are likewise expressed in rims, and which are 22 rims for the total height of the board, 6⅔ rims for the width above, 6 for the width below, ⅓ of a rim for the projection of the rim and 2 rims for its height.

The moulding of bells is usually done in the pit in which they are cast, and differs but little from the moulding in earth as practiced in iron foundries. It consists in making a brick core, bb, and a casing, ee, of earth, between which is placed a thickness of earth, ff, called the "false bell," and which is separated from the other parts by ashes, which prevent it from adhering and facilitate the removal from mould (Fig. 4). The drying of the mould may be hastened by burning fuel in the interior of the brick core.

The false bell consists of a mixture of earth and hemp kneaded by hand, so as to be easily removed and to avoid fissuration. It is this piece that receives the imprint or the relief of the ornaments that the bell is to bear, and to this effect moulding in melted wax is employed. As for the casing, that, likewise, consists of earth and hemp. Afterward the pit in which the mould is placed is filled in with earth, which is rammed down so as to consolidate the casing, in order that the molten metal may not distort it.

Before this, there has been put in place the mould of the ears that are to serve for fixing the bell to its yoke or beam. This moulding, which is quite a delicate matter, can be done with wax or with wooden or terra cotta models, in which care has been taken to leave divisions, such as ee, dd, in order to facilitate removal from the mould (Fig. 5).

The beauty of bells depends much upon the moulding clay, that is to say, upon the earth that covers the surfaces in contact with the metal. This moulding clay usually consists of very fine earth, to which is added about a quarter of cow dung.

After the mould is entirely finished, it only remains to effect the casting. The metal is melted in a large reverberatory furnace situated near the moulding pit. The one used for the casting of the Savoyarde is capable of holding 21,000 kilogrammes of bronze in fusion. Its sole is 2·6 m. in length by 2·1 in width.

Founders have discovered that it is advantageous to melt large quantities of metal at a time. When there are only small bells to be made, 30 or 40 are often obtained at a single casting. The preparation of the moulds, as we have just described it, is, moreover, quite a lengthy operation, and the same foundry generally makes but three or four castings a year.

The composition of bell bronze is, in round figures, 78 per cent. of copper to 22 per cent. of tin; but, on account of the oxidation that occurs during the casting, it is necessary to increase the quantity of tin employed in order to finally obtain the above-named proportions. It is quite difficult, moreover, to obtain an absolutely homogeneous material, and the more so in that the metals used are not always new, and often contain impurities, such as zinc. According to Mr. Guettier, the presence of the latter metal in small quantity has no perceptible influence upon the sound of a bell.

However this may be, the bronze of bells is richer in tin than that of guns. It is hard and brittle and cannot be worked in the lathe like the latter. The moulding is therefore very important, since the form obtained cannot be touched up. In order to give greater hardness and sonorousness to bells, they are allowed to cool slowly, for it has been remarked that temper, which gives so great hardness to steel, renders bronze, on the contrary, much more malleable.

It has often been said that old bells owed their sonorousness to a certain quantity of silver that entered into the alloy. It was, in fact, formerly the custom to baptize bells by throwing silver coin into the molten bronze, but the silver, instead of falling into the furnace, always managed to fall into the hands of the founders. Apropos of this, it may be of interest to state that an endeavor has been made in recent times to manufacture cast steel bells. These present some advantages over bronze ones as regards lightness and price, but inconveniences inherent to their manufacture have prevented their dissemination in France, and it is only in Germany and England that the use of them has spread. With an equal range and intensity of sound, the material employed for steel bells is half less than that for bronze ones, but the wear and oxidation of the metal counterbalance these advantages. It is very difficult to obtain steel so hard as not to be gradually injured by the clapper, and, at the same time, so slightly tempered as not to be too brittle. Besides, it is necessary to keep the surface of the bell oily so as to prevent oxidation.

The clappers of bells have for a long time been made of forged iron. Their weight is about one-twentieth that of the bell, and the diameter of the knob is generally one rim plus one-fifth. The connection of the clapper and the bell is effected through leather thongs passing through the ring of the bell and the eye of the clapper.

Bells are suspended through the intermedium of a piece of wood called the beam or yoke. The yoke of the Savoyarde is a magnificent piece formed of squared heart of oak with sharp edges, and weighing more than seven tons (Fig. 6). It will be understood that a beam of such a size would not be necessary if it were only a question of suspending the bell. The raison d'etre of this huge piece is that it has a certain influence upon the play of the apparatus when the bell is set in motion.

The Savoyarde was cast May 13, 1891, at Annecy-le-Vieux. After remaining for more than four years in the establishment of the Messrs. Paccard, it was hauled by twelve yoke of oxen to the station of Annecy, whence it was shipped to the Paris-Bercy

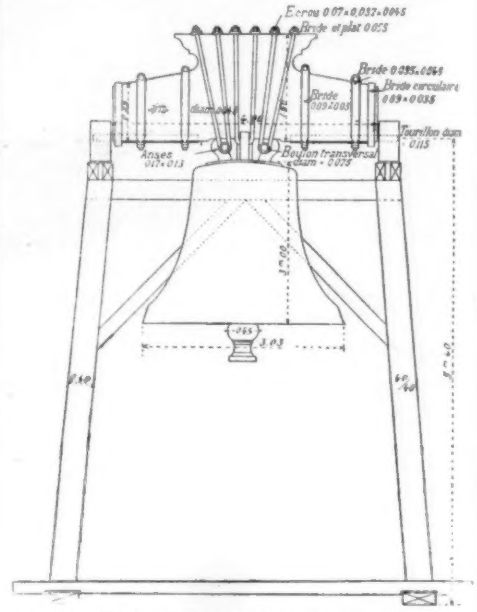


FIG. 6.—THE SAVOYARDE IN ITS PROVISIONAL BELFRY.

station. In order that it might not have to make too long a journey through the streets of the capital, it was afterward taken by rail to Chapelle, which is the nearest station to the Church of the Sacred Heart. But the carriage to be effected by wagon was nevertheless considerable. The service of roads and bridges, in fact, refused to allow the bell to be carried over the metallic bridges of Ordener Street and the Boulevard de la Chapelle, which cross the tracks of the Company of the North, so that the convoy had to descend through Chapelle Street and the Faubourg Saint Denis to the Boulevard Magenta, and then ascend the latter and the Boulevard Barbes as far as to the point of junction of the Boulevard Ornano with Ordener Street. The length of the journey was thus doubled.

From Ordener Street the convoy entered Damremont Street, the junction point of which with Marcadet Street was not crossed without apprehension, since some repairs to the sewer vault had been finished only about four days previous. So M. Rauline gave orders to cross it with as great speed as possible. Afterward the convoy passed up Lamarck Street, the ascent of which, despite its gradient of 0·08 meter to the meter, presented no other inconvenience than that of requiring vigorous efforts on the part of the horses.

The unloading of the bell at Chapelle station and the loading of it upon the truck were easily effected by means of a 20 ton steam crane, as may be seen in Fig. 1. It is of interest to note that the truck, despite the immense weight to be carried, was suspended, such suspension having been obtained by six springs, each formed of thirteen strips of steel one centimeter in thickness.

In order not to interfere with traffic, the carriage had to be effected at night, the cortege being escorted

THE BELL DRAWN BY TWENTY-EIGHT HORSES.

by torch bearers. The bell started from the station at four o'clock in the morning and reached the summit of the hill at six.

As soon as the bell reached the point at which it was to be unloaded (Fig. 2), that is to say, in front of the south facade of the church, a part of the fence that surrounded the scene of operations was removed and the unloading was proceeded with. This operation was very easily effected by means of screw jacks and wooden rollers. The bell was thus transferred from the truck to a sort of wooden chair situated at nearly the same level, and then this chair, through rollers and a gin, was made to ascend an inclined plane formed of strong wooden beams. It was thus carried to a platform to the left of the church, where had been constructed a framework belfry (Fig. 6) in which it will await the construction of the belfry that is to finally receive it.—Le Genie Civil.

PORTLAND CEMENT.*

By SPENCER B. NEWBERRY.

THE Association of German Portland Cement Manufacturers includes representatives of 78 factories, of which 63 are located in Germany, 8 in Austria, 3 in Sweden, 2 in Denmark, 1 in Russia, and 1 in the United States. The total production of the German factories amounts to 11,350,000 barrels per year. The eighteenth annual meeting took place in Berlin last February, and the complete proceedings of this meeting have lately appeared. A number of important papers were presented, and the most prominent German cement experts took part in discussions of interesting modern questions relating to the chemistry and testing of cement. A brief abstract of the proceedings will therefore probably prove of interest to American engineers.

After the transaction of miscellaneous business, Dr. Goslich, of Stettin, reported on a question which had been referred to him. It appears that the United States agent of a German factory publishes a circular giving the results of tests of a number of German Portland cements, these results purporting to have been taken from the records of the royal testing station at Charlottenburg. The agent's own factory stands, of course, at the head of the list, the others appearing greatly inferior. It was stated that some of the tests at the station are made from samples taken from large shipments in actual use in building, others from samples sent direct from the factories, and that in the latter case the officers of the testing station have no proof that the samples come actually from the source represented. These tests should not, therefore, be made the basis of comparisons between the products of various factories. A resolution was introduced to the effect that the sense of the meeting was opposed to the publication of comparative tests for advertising purposes, with the intention of making the products of competing factories appear inferior. After considerable discussion the resolution was laid on the table, the chairman (Dr. Delbrück) remarking that the publication by one manufacturer of attacks upon another is not calculated to increase the respect with which German cement manufacture is regarded in America. Any manufacturer is free to claim whatever he sees fit for his own product; the complaint made refers only to reflections upon the products of others. In the opinion of the chairman, the publication of the discussion will be a sufficient warning against bitterness and enmity in the business competition of the members of the association.

REPORT OF THE COMMITTEE ON UNIFORM TESTING APPARATUS.

The committee submitted a list of articles, with dimensions, necessary for testing cement according to the official requirements. Dr. Böhme's hammer apparatus, used for making briquettes and cubes for tensile and compression tests, was criticised and its defects pointed out. Owing to the more or less slanting blow which the hammer gives, it was suggested that it might be well to abandon the present trip hammer form and adopt the drop hammer apparatus now in use in Switzerland and Munich. A new form of briquette mould was also recommended, the outlines of which are formed of intersecting circles. It was claimed that this form is much more simple to make with mathematical exactness than the ordinary German form of mould, the curved outlines of which are rather complicated. Prof. Martens, of the Charlottenburg testing station, and Dr. Gary opposed the proposed changes on the ground that the hammer apparatus and present form of briquette mould are already in most extensive use by manufacturers and engineers, and the substitution of apparatus of new design would cause widespread inconvenience. In their opinion the efforts of mechanicians should be directed toward the correction of existing defects in the hammer apparatus and the production of moulds of uniform outline and accurate workmanship.

The committee reported favorably on the Amsler-Laffon press for compression tests, pointing out its great superiority over similar machines of other make, and stating it to be the press of the future. Dykerhoff stated that an Amsler press had been supplied for the experiments on the effect of sea water on cement, now in progress at the island of Sylt, and a similar one for the Dykerhoff factory at Amöneburg. Twelve cubes of cement and sand were prepared, of which six were tested at Sylt and six at Amöneburg. The results were 410·5 kilogrammes per square centimeter in one case, and 416·5 kilogrammes in the other; a close agreement

Dr. Prüssing, of Hemmoor, showed a new and greatly simplified compression press designed by him, a drawing and full description of which appears in the official report of the meeting. According to Dr. Prüssing, the chief reason why compression tests of cement are so seldom made is the high cost of the apparatus necessary. The new press is, however, very simple in design, and can be sold at a price of 350 to 400 marks ($87 to $100). It is claimed to be sufficiently accurate for the needs of engineers and architects.

Dr. Prüssing also exhibited and described an apparatus for representing graphically the progress of the setting of cement. The apparatus was invented by Prof. Goodman, of Leeds, England. It consists of a trough in which runs a wheel driven by clockwork. The trough is filled with the paste of cement and water, and the apparatus set in motion. As the cement sets, the wheel gradually rises, running along the surface of the mass when the setting is complete. The curve thus described is recorded by a pencil on a sheet of paper at the back of the apparatus. The best cements show a nearly horizontal line for some hours, then a quickly rising curve, reaching its maximum within an hour and a half after the setting begins. Certain inferior cements show a curve which begins within twenty minutes but is not complete within many hours. (A similar apparatus was constructed several years ago by Prof. E. A. Fuertes, of Cornell University, and is still in use in the cement testing laboratory at that institution.)

REPORT OF THE COMMITTEE ON REVISION OF THE OFFICIAL REQUIREMENTS FOR CEMENT TESTING.

The committee proposed that to the official definition of Portland cement, "a product obtained by burning an intimate mixture of lime and clayey materials to the point of sintering and grinding the resulting clinker to powder," should be added the following: "Cement which contains more than 5 per cent. of magnesia is not to be considered true Portland cement." (The question of the effect of magnesia was fully discussed on the following day, and will be referred to later.) The committee further proposed that all recommendations in regard to tensile strength tests of neat cement be omitted from the requirements, leaving the test with three parts of sand the only one officially recognized. This proposal was made in consequence of the very misleading results obtained by tests of neat cement, such tests being generally recognized by manufacturers to be of doubtful value.

It was further suggested that it might be well to make a change in the fineness of the normal sand used for testing. The present requirement is that this sand should pass a 20-mesh and be held by a 30-mesh sieve. It was stated that this sand gives lower results when used in testing cements than some ordinary building sands, owing to the complete absence of the finer particles. The public, therefore, sometimes draws erroneous conclusions from these tests, considering the resulting figures to represent absolute strength, while they should be considered as only relative. No definite action was taken on the recommendations of the committee.

REPORT OF THE COMMITTEE ON THE INFLUENCE OF MAGNESIA IN CEMENT.

The majority of the committee, Dr. Schott, Herr Meyer and Dr. Arendt, reported as follows:

"Our investigations, in part extending over a period of five years, have failed to show an injurious effect from magnesia in Portland cement, in the composition of which the magnesia replaces an equivalent amount of lime."

Dykerhoff, another member of the committee, could not agree with this view, his experiments having led him to a very different conclusion, a statement of which was given in a minority report, the substance of which is given below.

Dr. Meyer described at length the experiments which led the majority of the committee to the conclusion that magnesia is a harmless ingredient in Portland cement. According to Dr. Meyer, this is always the case if the relation between the proportions of lime and magnesia on the one hand and silica, alumina and iron oxide on the other remain normal. So long as the ratio of silica plus alumina plus iron oxide to lime plus magnesia does not exceed 2·2, the presence of magnesia up to 8 or 10 per cent. caused no harmful expansion or cracking in the cement, even after several years. Further, any considerable percentage of magnesia in the raw material makes it extremely fusible and very difficult to burn properly without melting to a glass. For this reason cements containing much magnesia are practically shut out from consideration, owing to the impossibility of their passing the standard requirements as to tensile strength. It was therefore recommended that the resolution of the committee be adopted, and that thus a number of manufacturers should be relieved from the unjust requirement that the amount of magnesia contained in Portland cement should not exceed 3½ per cent.

Herr R Dykerhoff then gave an account of his own experiments on this question. In these experiments the proportion of lime was purposely kept low, the ratio $SiO_2+Al_2O_3+Fe_2O_3$: CaO being 1·83.

Two series of mixtures were made; in the first, magnesia was added to the mixture in various proportions up to 21 per cent.; in the second, the same amounts of magnesia were substituted for equal amounts of lime. The charges were burned to complete sintering, and all over or under burned portions were rejected. The resulting cements were tested for tensile strength with 3 parts sand, and for expansion, at intervals up to five years. Complete tables, showing the results in detail, are given. These results may be briefly described as follows:

1st. Magnesia added. Tensile strengths at four weeks about equal up to 18 per cent. magnesia. All showed good increase in strength up to six months, after which time the cements with 17 and 21 per cent. magnesia showed decided falling off in strength.

After two years all cements with over 4 per cent. magnesia showed a decrease in strength. At the end of five years the cements with 1 to 4 per cent. magnesia showed good strength, while those with 5 to 11 per cent. were weaker, and those with 17 and 21 per cent. magnesia showed a strength of 0. One cement with 6 per cent., lightly burned and not sintered, showed no noticeable decrease in strength in five years. Tests of expansion showed that in cements with 1 to 3 per cent. magnesia the expansion was slight up to one year, then practically ceased. With 4 per cent. and over the expansion during the later periods steadily increased with increased proportions of magnesia. Actual cracking was shown by the cement with 8 per cent. magnesia at the end of five years. Cements higher in magnesia all showed cracking at earlier periods.

2d. Magnesia substituted for lime. Two mixtures were made, with 6 and 11 per cent. magnesia. Both showed decided falling off in strength after six months, and both showed cracking at five years and three years respectively. Another cement, containing 18 per cent. magnesia, was lightly burned and not sintered, and showed steadily increasing strength and freedom from cracking up to five years.

From these experiments, Dykerhoff concludes that the harmful effect of magnesia in Portland cement is due to the dense condition which it assumes at the sintering temperature, in consequence of which the magnesia becomes hydrated only very slowly, and during hydration shows marked expansion. In light burned cements, on the other hand, like the American natural rock cements, the magnesia is in a far less dense condition, and readily becomes hydrated without injurious expansion. This view was confirmed by the addition of, strongly sintered magnesia, separately prepared, to a cement nearly free from magnesia. With 10 per cent. sintered magnesia the strength was 0, and cracking appeared after two years. With 20 per cent. the cement disintegrated in four weeks. Light burned magnesia (magnesia usta), added in the same proportions, produced no injurious effect. Dykerhoff summarizes his conclusions as follows:

"The presence of magnesia up to 3 per cent. in Portland cement produces no change in its properties. From 4 per cent. on, however, magnesia, if sintered, whether added or substituted for part of the lime, has an injurious effect, producing increased expansion and decreased strength after long periods. This injurious effect is the stronger the higher the percentage of magnesia. If the cement is not sintered, however, a high proportion of magnesia, even 18 per cent., may be harmless."

Dykerhoff referred to the alarming results which strongly magnesian cements had given in England, France and Germany, on which he reported fully at the 1889 meeting, and which led him to investigate the effect of magnesia. The chief danger to the consumer lies in the fact that the evil effects of magnesia show themselves only after long periods, and cannot be detected by the usual short time tests. In consequence of the wide disagreement in the results obtained and the views held by the different members of the committee, Dykerhoff recommended that a new committee be appointed, to carry on further experiments in connection with the Royal Testing Station. Considerable heated debate ensued, in the course of which the chairman read part of a letter from Dr. Erdmenger, in which the writer stated that he could not indorse the resolution of the majority to the effect that magnesia is entirely harmless. Such a complete overturning of the prevailing dread of magnesia would be likely to cause doubt and perplexity. It is evident that in many places the use of strongly magnesian materials has produced uncertainty in the manufacture, and that in spite of the fact that almost every factory could point to good and lasting results, the general tendency has been to avoid the use of materials containing a high proportion of magnesia. To make matters somewhat easier for manufacturers using magnesian material, he recommended that the allowable limit of magnesia be placed at 5 per cent. instead of 3½ per cent.

The resolution of the committee was voted down, and the whole question referred back for further investigation to the same committee, with the addition of Professor Martens, of the Royal Testing Station, and others.

REPORT OF THE COMMITTEE ON THE ACTION OF SEA WATER ON CEMENT.

Herr Dykerhoff gave an account of the experiments in progress at the island of Sylt. These experiments are carried on at the joint expense of the German government and the Cement Makers' Association. It has generally been supposed that the presence of high percentages of alumina and sulphate of lime in cements rendered them more liable to attack by salt water. Tests were made with cements containing 5, 7·7 and 8·8 per cent. of alumina, with and without the addition of 1 and 2 per cent. of ground gypsum.

These cements were tested with 4 parts sand, and also with the addition of ¼ part of lime paste (slaked lime). Up to the present time all these mixtures show about the same result, from which it appears that within certain limits the presence of higher proportions of alumina and sulphate of lime has no appreciable effect on the hardening in sea water.

It was found, however, that briquettes of cement lime mortar were somewhat attacked by sea water after 1½ to 2 years. Candlot, in France, has pointed out the same effect. Since, in marine construction, moreover, a high degree of resistance is necessary, the testing of cement lime mortar has been discontinued in the experiments at the island of Sylt. Herr Sympher, inspector of construction at the North Sea Canal, is carrying on a series of tests of the effect of sea water on cement sand mortar. Up to 13 weeks the tests in sea water are on the average 20 per cent. lower than in fresh water.

Herr Sympher, in a communication to the association, reports that, in spite of the high quality and reduced price of modern Portland cements, the cost of cement mortar and concrete still reaches so high a figure that in some cases efforts must be made to find some cheaper material. This was the case in building the great gates and basins of the canal. Substitutes for Portland cement are found in hydraulic lime and Pozzuolana cement. Hydraulic lime is, however, objectionable on account of its slowness in hardening. Pozzuolana cement and other similar materials not claiming the name of Portland cement often show qualities which are in no way inferior to those of true Portland. The materials are, however, very variable. One excellent Pozzuolana cement proved utterly unfitted for use in sea water; another, which showed at first very high tests, fell off astonishingly in strength after storage for a few months in a dry warehouse. On this account the use of such materials was discontinued, and economy secured by lessening the proportion of Portland cement and replacing part of the cement by slaked lime. With one part of cement to eight, ten, or even twelve parts sand, concretes were obtained which fulfilled all usual requirements. The masonry of the Baltic Sea gates is chiefly built with mortar consisting of one part cement, one-half part lime and four parts sand. Thorough mixing is essential in the production of good cement lime mortar. This was secured by the use of mixing pans with edge runners. Tests of the cement lime mortar 1 : ½ : 4, taken from

* Report of the annual meeting of the Association of German Portland Cement Manufacturers.

the mixing pan, showed at twenty-eight days a tensile strength of 368 lb. per square inch, while briquettes of the same cement with three parts sand, made in the laboratory with the hammer apparatus, showed only 312 lb. Mixing pans are, however, seldom available in practical work, and Herr Sympher suggests that the cement and slaked lime should be mixed at the factory to insure a perfect mixture. This plan was opposed by Dykerhoff, on the ground that the proportion of slaked lime required is not always the same, and that the expense of packages and freight would make the lime far more costly to the consumer than it would be if bought where it is to be used. Dykerhoff suggested that efforts be made to induce manufacturers of machinery to supply mixing pans of simple design and low cost, suitable even for work on a small scale, since by their use the results obtained from cement lime mortar can be immensely improved.

ON THE PROCESS OF HARDENING IN PORTLAND CEMENT.

Dr. Tomei presented the results of a series of experiments on the action of solutions of ammonium chloride and of caustic soda on cement after various periods of hardening. It was found that the amount of lime, silica, and alumina extracted by these solvents diminished greatly with increasing age of the briquettes, both in the case of neat cement and cement with three parts sand. Much more silica was extracted from the sand briquettes than from those of neat cement, indicating a marked chemical action of the cement on the sand. Thin sections of hardened cement, under the microscope, showed a dense fine-grained groundwork, intermingled with a transparent, glassy mass which showed no action on polarized light. This was considered to be colloidal, hydrated silica. With increasing age of the briquettes this material shows a more and more distinctly crystalline character. It thus appears that colloidal silica plays an important part in the ultimate hardening of cement.

Dr. Tomei, and also Dr. Kosman, gave an account of the measurement of the heat of setting of cement by means of a calorimeter. The thermometer used was graduated to $\frac{1}{50}$ of a degree. Twenty grains of cement were placed in a small metal box, water to the amount of 32 per cent. added, and the box closed and dropped into the apparatus. The standing of the thermometer was noted at intervals, and the experiment considered finished when no further rise of temperature took place. With commercial cements this point was reached in from one to nine hours. Well burned plaster of Paris was found to evolve 30 calories; quicklime, 277 calories. The following were some of the results obtained with cements:

Stettin cement, slow setting	9·33 cal.
" " quick setting from long storage	7·75 "
Stettin cement, slow setting from addition of ½ per cent. gypsum	3·60 "

A number of other papers were presented, chiefly of such a character that no brief abstract of their contents can well be given. Among these may be mentioned that by M. Gary, on the use of cement sewer pipes, and by Dr. Goslich, on concrete and other uses of cement. Full reports on new forms of grinding apparatus were presented and discussed, in the course of which the American Griffin mill and the German horizontal ball mill were fully described. Dr. Schoch described a new form of continuous kiln, consisting entirely of cast iron rings, one resting upon another. In this kiln the radiation of heat keeps the walls cooled to such an extent as to protect them from injury, and also to prevent the adhesion of the hot clinker. Illustrations of the peculiar form of dumping grate employed are given in the report.

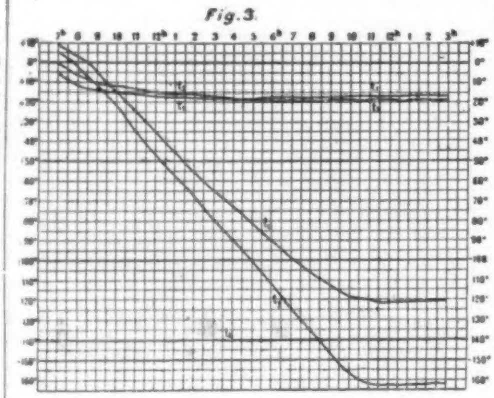
THE COMMERCIAL MANUFACTURE OF LIQUID AIR AND OXYGEN.

A PAPER which, but for its sobriety of promulgation and validity of reasoning, might fitly be termed sensational, was read by Herr M. Schröter before the general meeting of the Association of German Engineers, held recently at Aachen—or Aix, as some term it. The essential features of this communication are here transcribed.

The condensation of difficultly condensible or so-called permanent gases is beset by the impediment that pressure alone is incapable of bringing about the end desired. Liquefaction cannot be achieved unless the gas be below its critical temperature. For gases commonly condensed to the liquid state on a commercial scale, the critical temperature is fairly high, e. g., for carbonic acid it is about 30° C., i. e., 86° F. For the main constituents of air, however, the critical temperature is far below zero Centigrade, and the attainment of so low a temperature has proved a greater obstacle than the production of the high pressure which is simultaneously requisite. The plan usually adopted consists in liquefying one gas by pressure at a low temperature produced by the evaporation of another more readily condensible, and utilizing the liquid thus obtained for cooling a yet less easily condensible gas to a temperature below its critical point. Thus carbonic acid and ethylene are convenient intermediaries in progressing from the ordinary temperature to the critical temperature of liquid air (say —140° C. = —220° F.) It is evident that a series of coolings thus arranged constitutes a laborious method of procedure, and the cost of the product is too great to allow of the application of liquid air for any but scientific purposes. A step has now been taken which removes the preparation of this particular material from the laboratory to the factory, and makes it as much a matter for the thermal engineer as is the design and running of an ordinary freezing machine. A few preliminary considerations are requisite for a comprehension of the rationale of the device about to be described.

It is indicated by theory that a freezing machine working with an easily liquefiable gas, e. g., carbonic acid or ammonia, would give a better result if the expansion of the compressed and partly liquefied gas were to take place in a cylinder in which it could do work, instead of through a throttle valve through which it merely blows off, changing in so doing from the liquid to the gaseous condition. In practice, however, the gain which would thus accrue is too small to be of importance, because the amount of work that could thus be taken out of a vapor much below its critical point is vastly smaller than that which is involved in its change of state. Again it is generally assumed that in the case of a cold air machine it is essential that the compressed air shall, in expanding, do work, for otherwise—there being no change of state as the gas is far above its critical point—the final temperature after expansion, when all parts of the system have attained equilibrium, will be equal to the initial temperature, and no cooling will be effected. This is not strictly correct, for it presupposes that air is a perfect gas in which no intermolecular work is possible. It is true that the amount by which air departs from the behavior that may be postulated for a perfect gas—an imaginary entity—is not great, but it is perceptible, and what is more, was measured by Joule and Thomson forty years ago. These experimenters found that dispensing wholly with a cylinder in which compressed air could do work, and using only

Fig. 3.



an outlet in the manner practiced for freezing machines, using easily liquefiable gases, the air was definitely and permanently cooled. The formula connecting the cooling effect with the original temperature and initial and final pressure of the gas may be written:

$$\text{deg.} = \frac{p_2 - p_1}{4}\left(\frac{289}{T_1}\right)^2$$

p_2 is the higher and p_1 the lower pressure in atmospheres, and T_1 the absolute temperature of the compressed air just before it passes the point of expansion. When $p_2 - p_1 = 10$, and $T_1 = 0°$ C., the cooling effect $S = 2·64°$ C. This cooling effect is so inconsiderable that it appears at once that a cold air machine with merely a throttle valve, and without an expansion cylinder, would be a valueless contrivance. It is therefore the more remarkable that Linde, the inventor of the apparatus shown in Figs. 1 and 2, should have been able to utilize this small difference in such a way as to cause it to yield a cumulative effect great enough to permit the attainment of the critical temperature of air, and, as an immediate and necessary consequence, of temperatures still lower, e. g., —200° C. = —328° F., by simply handling liquid air like any other volatile liquid.

A diagrammatic view of the apparatus is given in Figs. 1 and 2. P_1 is the inlet and P_2 the outlet pipe of a compressor. The compressed air is cooled to about 10° C. = 58° F. by an ordinary water jacket, marked "cooler" in the figure. The air then passes down the "reverse flow cooler" shown on the right hand side of Fig. 1. It will be seen that connection with the outer annular space of this cooler is entirely cut off by a diaphragm at each end. The air flows through the throttle valve and expands, doing work and becoming slightly cool. Thus with a pressure of 75 atmospheres on the upper side of the valve, and one of 25 atmospheres on the lower, air at an initial temperature of 10° C. is cooled through — 12·76° C. in accordance with Joule and Thomson's formulæ (see above). The slightly cooled air flows by the side tube leading from the "receiver" — see Fig. 1— into the annular casing of the reverse flow cooler, its course being indicated by the direction of the arrows. In thus flowing it receives heat from the air streaming along the inner tube in the contrary direction and about to pass the throttle valve, which is correspondingly cooled. This cooled air in its turn passes the throttle valve, and is again cooled by its expansion, and serves to cool the next portion about to pass the throttle. The air flowing upward is, at the point where it enters the annular case, at the low temperature attained a moment before by passage through the throttle, and the air on the point of passing the throttle is at the temperature which the portion next before it has reached by its own passage through the throttle. A gradation of temperature from the lower to the upper end of the reverse flow cooler obtains in both inner and outer sections thereof, and at the upper end both streams of air are at substantially the same temperature, viz., that fixed by the water jacket through which the delivery pipe of the compressor passes. The return current of air passes at this temperature back to the compressor, and is there driven once more through the system, heat due to the stroke of the compressor being taken up by the water jacket, so that air at a temperature not higher than 10° C. is constantly delivered to the upper end of the inner tube of the reverse flow cooler. In practice this most essential portion of the apparatus (shown for simplicity as two straight concentric tubes, see Fig. 1) consists of two spiral tubes, one within the other, 100 m. long and 10 and 4 cm. in diameter respectively. The whole is of course elaborately lagged to prevent the absorption of heat from external sources. The cycle of operations, consisting of compression, expansion, and cooling, continues until the temperature of the air in the apparatus falls in the receiver to a point below the critical temperature of air. A portion of the air thereupon liquefies, and a fresh quantity is accordingly introduced into the system by a second compressor (not shown) which serves to feed the main or circulating compressor. The process continues as before, until a sufficiency of liquid air has collected in the receiver.

The curves shown in the diagram (Fig. 3) give a complete history of one of the earliest trials made at the Munich testing station of the Linde Freezing Machine Company. The initial temperature, t_1, was in this case below 0 deg. C., cooling being effected by an ammonia freezing machine instead of water, which would be adopted for permanent work. In consequence of this slightly lower initial temperature, the temperature of the return stream of air, t_4, is (see also Fig. 1) below 0 deg. C. These two temperatures are substantially identical, as, indeed, they should be with proper transference of heat from one side to the other of the reverse flow cooler; t_2 (see also Fig. 1) is the temperature on the high pressure side of the throttle valve, and t_3 that on the expansion side of the same valve. The gradual separation of these curves is in conformity with Joule and Thomson's equation; t_4 is the critical temperature which has to be passed before liquefaction can occur, whatever the pressure. The lower temperatures given in this diagram were measured by an electric resistance thermometer. In considering the comparatively slow rate of cooling as given by the abscissæ, which are in hours, it must be remembered that not only the air, but also a portion of the apparatus had to be cooled to a low temperature. At the first trial about eight liters of liquid, slightly blue in color, were obtained.

It follows from Joule and Thomson's equation, and from the known relations of the adiabatic compression of gases, that the apparatus is best worked with as large a difference of pressure and with as low a ratio of pressures as possible. Thus, high absolute pressures should be used, e. g., 150 and 50 atmospheres for the two sides of the throttle valve, these values giving a difference of pressure of 100 atmospheres and a ratio of 1 : 3. Such pressures, though high, are already used in practice for torpedoes and hydrogen cylinders for inflating military balloons.

So much for the liquefaction of air on a commercial scale; it remains to consider the production of oxygen from the air thus liquefied. Analysis of the gas produced by the evaporation of the liquid product obtained in the manner already described showed that it contained 70 per cent. of oxygen—in place of 21 per cent., the quantity present in normal air. It was evident, therefore, that a segregation of the constituents of air had taken place. The cause of this phenomenon is simply that, as nitrogen boils off from liquid air more quickly than does oxygen, the residual liquid contains more oxygen than is proper to normal air. It is, therefore, practicable to manufacture oxygen from air by purely mechanical means. Seeing that this separation is at present to be regarded as an end of which the preparation of liquid air is only a convenient means, a modification of the apparatus, capable of utilizing the

Fig. 1.

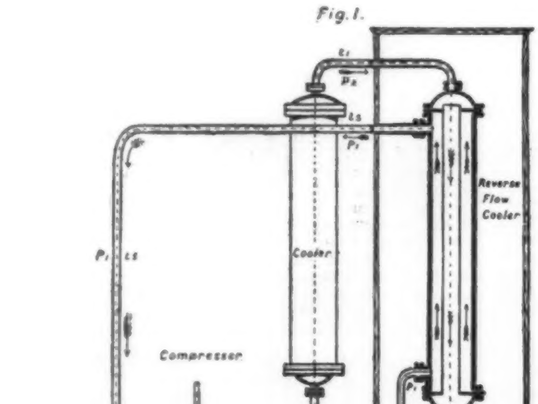
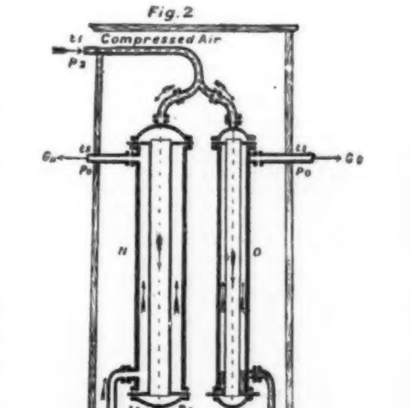


Fig. 2



cooling effect of both liquefied constituents, and thus finally evolving them at the same temperature as at the beginning of the operation, but as separate gases, is worthy of description.

The additional arrangements shown in Fig. 2 suffice for this purpose. The reverse flow cooler is duplicated, the second member being connected with the first above the throttle valve through the spiral tube shown coiled in the receiver. As the gas condenses in the receiver, oxygen is its preponderating constituent, and this is allowed to flow out by pipe R^1, which is trapped by liquid oxygen into the reverse flow cooler, O, nitrogen correspondingly finding its way from the space above the liquid into the outer jacket of the reverse flow cooler marked N. In these two coolers the expansion of each gas on its release by drawing off through the pipes, G_n and G_o respectively, aids in the cooling effect on the air delivered by the compressor down the inner tube of each cooler, this action being superadded to the cooling normally resulting from passage through the throttle valve. The richness in oxygen of the gas passing out through G_o can be controlled by regulating the throttle valve, and thus liquefying the air selectively, or en bloc, as may be desired.

With regard to the power required for the production of liquid air by this method, it is found by calculation that a horse power hour should give about 1 cubic meter of 70 per cent. oxygen. An economy in power can probably be effected by maintaining a pressure of about 4 atmospheres in the receiver, and allowing the gas, rich in nitrogen, coming from the reverse flow cooler, N, to do work by expanding in a cylinder, and utilizing the resulting lowering of temperature for cooling the incoming air. Working with an initial temperature such that $t_1 = -30$ deg. C., the value $p^1 - p_1$ can be reduced to 22 atmospheres, giving a total pressure to be produced by the circulating compressor of $22 + 4 = 26$ atmospheres. A portion of the work represented by the back pressure of 4 atmospheres could also be recovered.—The Engineer.

MANUFACTURE OF PHOTOGRAPHIC PLATES.

THE manufacture of photographic plates has become an important industry. While facilitating the business of the photographer, or of the simple amateur, it has greatly contributed to the arts of reproduction. In fact, in the work of the photographer, the most difficult, delicate and lengthy matter is the preparation of the glass plates upon which the sensitized emulsion is spread.

The manufacture of the plates is a very interesting industry in the sense that the processes and apparatus that it utilizes are special to it and much improved. We are going to give it in all its details. We have taken as our model the manufactory of the Messrs. Lumiere, at Lyons. These gentlemen, with their usual politeness, have been kind enough to give us permission to visit their works, and to allow us to take the photographs that accompany this article.

CUTTING OF THE GLASS.

The glass reaches the establishment in sheets analogous to window panes, packed in boxes that contain from 260 to 300 pounds each. The Messrs. Lumiere use two car loads of glass every three days, representing about 44,000 pounds, or between 13,000 to 15,000 pounds daily. The quality of the glass employed is not an indifferent matter, it being either carefully selected or of Bohemian manufacture. It must be free from bubbles, striæ, scratches, roughness and other defects, which would be reproduced in the printing of positives. It must be polished and plane, so as not to produce irregularities in the thickness of the film.

The first operation consists in cutting the panes of glass into strips having, as to width, the dimensions of one of the sizes in most common use, and as to length that of the sheet, say from 20 to 24 inches. Thus, for the sizes 3·6 × 4·8, 4·8 × 6·5 and 4·8 × 8 the glass is cut into strips 4·8 inches in width. When they are finished, these strips are afterward cut into widths of 3·6, 6·5 and 8 inches, in order to obtain the sizes demanded. For the sizes 3·6 × 5, 5 × 7 and 7 × 9·5, the strips are cut 7 inches in width, and for the sizes 4·4 × 6, 6 × 8 and 6 × 8·8, the strips are 6 inches in width.

The cutting is done by women in a room well lighted by the sun (Fig. 1). The operatives, provided with a wooden straight edge, cut the edges of the plates in order to remove the fractures and inequalities, and also to render the plates absolutely true. Afterward, they cut the sheets into strips 4·8, 6 and 7 inches in width. During this first operation the first sorting of the plates is effected.

CLEANING OF THE GLASS.

The plates that are to receive the emulsion must be perfectly clean and free from grease or other spots. They are first washed with water to remove the dust with which they are covered. In order to deprive them of foreign matter, they are plunged into bichromate of potash acidulated with sulphuric acid, and are then washed with an abundance of water. In many establishments this work is still done by hand. In Germany and America they use machines composed of washing, polishing and other rollers. At the Messrs. Lumieres' a special machine of their invention cleans the plates to perfection. This machine, run by two persons, permits of cleaning 43,000 square feet a day. If this same surface were to be cleaned by hand and in the same time, it would require a force of 1,000 persons.

A plate is well cleaned when, being immersed in water and taken vertically from the bath, it is uniformly wet, and its surface presents no striæ produced by capillarity upon the thin stratum of water that covers it. The plates are afterward dried by a gentle heat under protection against dust.

PREPARATION OF THE EMULSION.

We do not know the formula used by the Messrs. Lumiere, and so give that of Eder.

One begins by preparing the three following solutions: (1) 4,500 grains of hard gelatine in 5 quarts of water; (2) 1,000 grains of hard gelatine, 1,000 grains of bromide of ammonium and 90 of iodide of potassium in 2 quarts of water; (3) 1,500 grains of nitrate of silver, and from 15 to 30 of nitric acid in 18·750 of water. These three solutions are prepared in earthen or glass vessels of a capacity of from 5 to 7 quarts (Fig. 2). The laboratory that serves for this manipulation is illuminated by daylight. From this moment on, all the operations are effected in darkness, by green light. Green light was adopted by the Lumieres because red light has the inconvenience of greatly fatiguing the sight of the operatives and causing in certain of them ophthalmic diseases that green light has never occasioned.

The emulsion is prepared in a dark laboratory by gradually pouring the solution of nitrate of silver into that containing the bromide of ammonium and gelatine. This is effected at a temperature of 40°, so that the gelatine shall be still liquid. There forms bromide of silver and nitrate of ammonia. The liquid becomes milky. One adds the solution of gelatine and keeps the emulsion for an hour at a temperature of 40°

FIG. 2.—PREPARATION OF SENSITIZED EMULSION.

in agitating it from time to time. When it has assumed a greenish blue tint, it is allowed to cool.

The solidified emulsion is passed through muslin or silver gauze. It is converted into thin vermicels, which are placed in a vessel full of water. The water is decanted and replaced by fresh every five minutes.

The object of this washing is to remove the salts produced by the double decompositions that are accomplished during the operation.

The emulsion is expressed and put into pots in which it is allowed to "ripen" in darkness for five or six days. The object of this ripening is to increase the sensitiveness of the bromide of silver. At the end of this time the emulsion is ready, and one melts it in a water bath and sends it to the machines for spreading it over the glass plates. This is the most delicate part of the manufacture, for upon the proper preparation of the gelatino-bromide depends the value of the plates. The Messrs. Lumiere bestow great care upon this. Every vessel used in the manipulation of the gelatino-bromide is of silver, and frequent tests give certain indices as to the value of the preparations.

SPREADING THE EMULSION.

The emulsion is spread over the plates by means of a machine that we have already described in these pages. The Lumieres have improved machines, a description of which would present only a technical interest. The plates are placed upon endless chains that run over two rollers and are connected with each other by small iron rods, so as to form a sort of wire cloth with wide meshes. The plates are carried along by the motion of the chains and pass under the automatic distributer of emulsion, which equalizes it in a uniform and perfect manner over the entire plate. The tepid emulsion is contained in a special box.

After this motion, the plates covered with emulsion are taken by a second endless belt composed of a fabric forming a sponge. This belt plunges into a bath of ice water, and the plates upon coming over this are instantaneously cooled and the gelatino-bromide solidified. At the extremity of the endless belt the plates are taken up and carried to a drier.

The room in which the emulsion is spread upon the glass is kept very clean, and no dust must enter it. So, as a measure of precaution, the operatives who attend to the machine and drivers do not wear linen gowns, but dress in blue cloth and wear pantaloons. The walls and ceiling of the room are constantly moistened with an abundance of water.

DRYING OF THE PLATES.

The drying of the plates is effected in a drier in which dry air constantly circulates. The drying of the air is effected by causing it to pass over a bundle of tubes in which ice water circulates. The air is cooled and deposits its humidity. It is afterward brought to the ordinary temperature and sent to the drier. The plates are placed, unprepared side down, upon supports.

CUTTING OF THE PLATES

The strips of glass are cut with a diamond to the desired size by operatives working in darkness. They scratch the glass on the side of the sensitized layer, and, with a sudden blow, detach the pieces. This operation is something curious to witness. It requires skill of hand to perform it well. The plates are submitted to a careful examination by several operatives,

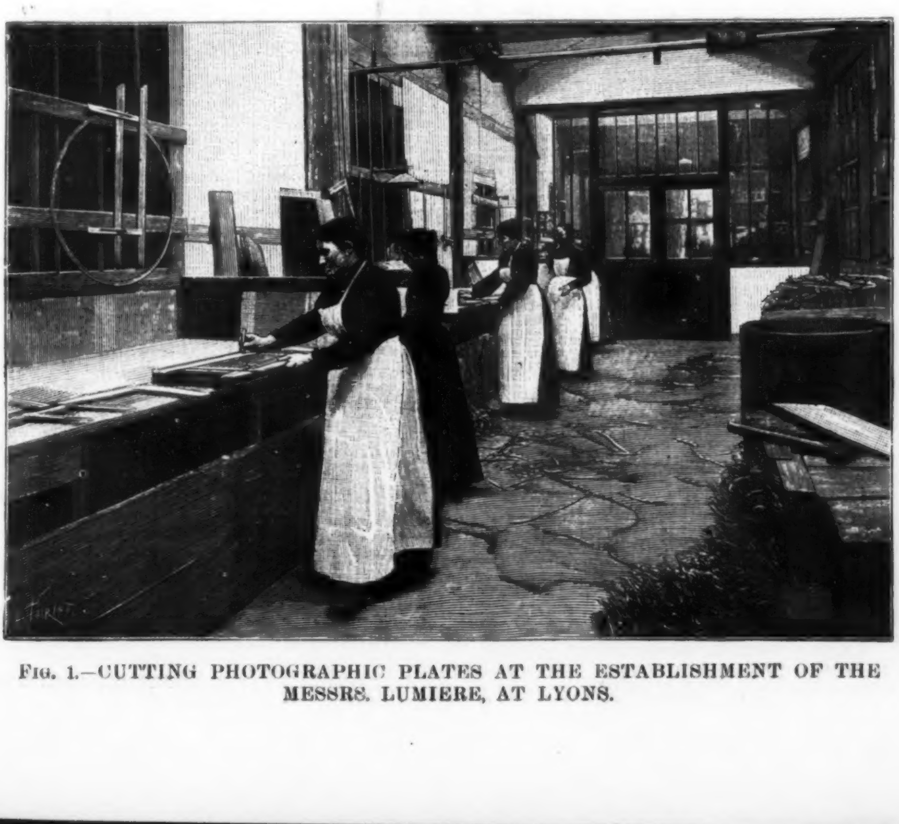


FIG. 1.—CUTTING PHOTOGRAPHIC PLATES AT THE ESTABLISHMENT OF THE MESSRS. LUMIERE, AT LYONS.

and all those plates that show defects are thrown aside. Those that are perfect are sent to the packing room.

PACKING.

The cards that serve to separate the plates from each other are cut out by a machine. Another machine folds them in two in V form. On the two opposite sides of each plate is placed one of the folded cards, and the plates are piled up in dozens. They are wrapped in orange-colored, red or black paper. Sometimes they are divided into packages of 6, each wrapped in red paper and covered with black paper. The whole is put into a cardboard box surrounded with paper, to which are affixed bands and factory labels.—La Nature.

[Continued from SUPPLEMENT, No. 1041, page 16641.]

RAILWAY SIGNALING.*

By W. McC. GRAFTON, C.E., Signal Engineer, Pennsylvania Lines West of Pittsburg.

(3) ARRANGING the machine for moving switches and signals.

CONSTRUCTION OF INTERLOCKING MACHINES.

An interlocking machine consists of a number of levers placed in a row in a frame, each working about a center on a common horizontal axis. These levers are numbered consecutively, beginning with No. 1 at the left hand side of the machine when facing the levers. There are generally a few spare spaces left in each machine, and these spaces are each given a number the same as if the levers were there. The spare spaces are put in for convenience and economy, so that in case it is desired to connect another switch or two into the same machine it may be conveniently done. The machine is built in sections of four or eight spaces and the total number of levers is determined by the number of switches and movements to be made. The machine proper, that is the levers, frame and interlocking, are always put together in the shops. This is done in order to test the locking, before sending it out for erection, as it is easier to make corrections in the shop than it is outside. All the outside material which goes with an interlocking machine is fitted together on the ground when the machine is to be put into service.

An interlocking system is different in this respect from any other kind of machinery or structure which is designed for outside erection. For instance bridge material, structural steel for buildings, all kinds of engines and pumps, in fact, almost everything is planned, dressed, and fitted together in the shop, and when received at its destination is ready to be placed and bolted or riveted together. Even building stone is shaped and dressed at the quarries, and the individual stones are numbered ready to be placed in position. This explains how easy was the building of King Solomon's Temple, where there was not heard the sound of ax, hammer or any tool of iron. But in interlocking there is nothing but the machine proper that is fitted in the shop. After the track plan is adopted the material is taken out for so many pipe lines of such length, with bell cranks for turns, compensators, locks and bars for switches, etc. This material is always taken out for the shortest or most direct route to the switches and with a view to having as few turns as possible, on account of the increased friction and consequent extra wear on the connections, but after the material is received it often becomes necessary to change the leadout entirely. This involves no expense, as nothing has been cut or fitted together, but it simply requires the exchange of some of the material. You will see from this that there are no two interlocking plants which are just alike; and, while there are general principles to be followed in every case, there is an opportunity to apply them differently each time, and this takes away the monotony that might be supposed would exist in the life of the signal engineer.

Most interlocking machines are placed in a two-story tower, with the levers on the second floor. In some kinds of machines the locking is in front of the levers and above the floor in a horizontal plane, and in other kinds the locking is below the floor in a vertical plane. The former is the better locking, as in the latter all lost motion from wear and tear takes place in one direction. The connections from the levers to the switches and locks are made with a one inch wrought iron pipe put together with a collar, and an iron plug about six inches long which is placed three inches in each pipe and riveted through each. The pipe is run on sheave wheels two and one-half inches in their least diameter, and placed seven feet apart. The pipe is stiff enough not to buckle in this distance. In England there are a number of railroads that use a channel or U iron, which is both light and strong, instead of pipe. The connections from the levers to the signals are commonly made with No. 9 steel wire. It is now usual to have a front and a back wire, but it was common practice at first to have but one wire, which pulled the signal clear and gravity was depended on to throw it to danger. There have been quite a number of home signals coupled up with pipe in the last two years, and all signals should be pipe connected. Pipe connections to signals are better in every way, but up to the present time railroads have considered the pipe to be too expensive for this use.

LOCKING.

When levers were first assembled at the central point for the purpose of controlling a system of switches and signals, each lever worked independently of the other. This proved very disastrous, as the towermen sometimes set the switches for one route and gave the signals for another, thus causing serious wrecks. Expensive experience of this kind led to placing an arrangement of locking between the levers which made them dependent upon each other. Hence the name interlocking. This locking is of various styles, but all accomplish the same object, which is to so virtually control the levers of an interlocking machine that when the switches and signals are set for a particular route it is impossible to move any lever in the machine that will in any way endanger a train which is moving under the direction of the signals.

In setting up a route by means of an interlocking machine the switches are set first, then the facing point locks for each of these switches, then the home signal, and last the distant signal, if the route is a high speed one. The normal position of all levers in an interlocking machine is forward, in which case all the switches are unlocked and all the signals are at danger. Each lever, as it is reversed or pulled back, locks in position any lever which, if reversed, would conflict with the route which the first lever controls. When it is desired to return the levers which control a particular route to their normal position, the movements can only be made in the reverse order from the way in which they were originally made; that is, the distant signal first, home signal next, switch locks next and switches last.

I stated that each lever as it is reversed locks up each lever which, if reversed, would conflict with the route set. The interlocking does more than this. The best locking is what is known as preliminary or latch locking, which works as follows: When a latch attached to a lever is raised, it at once locks all levers that are required to be locked. While the lever is being reversed the locking mechanism remains stationary. When the lever is reversed and the latch is dropped it unlocks all levers that do not conflict. The locking mechanism being operated by means of the latch, an excessive strain cannot be placed on the locking, as an operator can only employ the leverage of the latch handle.

Latch locking came to us from England. The first American machine did not have it, but no mechanical interlocking machine is now considered complete without it. You will see from the above that as long as the signal lever of a given route stands reversed the route is locked up and one is free to move any lever in the machine which he can without any possible danger to a train on the route set up. As soon as the signal lever of the given route is returned to the normal position the lever controlling the switch lock is released and the switch can be unlocked, but to avoid possible danger at this point there is added to the switch lock what is called a detector bar.

FACING POINT LOCK AND DETECTOR BAR.

The switch lock and its detector bar (Fig. 13) are connected on the same pipe line, and while it is possible to have the lock or bar separate, the term "facing point lock" always implies a switch lock and a detector bar. The bar is a piece of flat iron 2¼ inches by ⅜ inch and longer than the distance between the trucks of the longest cars. It is placed along the rail and fastened to it by arms or slide plates. When the switch is locked the bar is below the top of the rail and the wheels pass over without touching it, but in order to unlock the switch it is necessary to raise the bar above the rail, and if an attempt is made to unlock a switch while a train is passing over it the detector bar strikes the wheels and prevents the unlocking. In this way a train holds a switch locked after it starts over the detector bar.

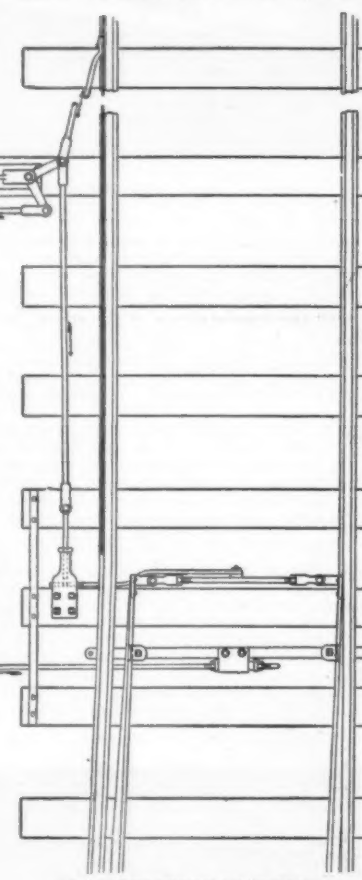


FIG. 13.—Facing point lock and detector bar.

ELECTRIC LOCK.

There is also an electric locking which can be attached to the interlocking machine as an additional safeguard against throwing a switch while a train is passing over it. This is arranged by cutting a slot in the flop of the lever which must be locked, and a latch is held out of this slot by an electric current which flows through a circuit partly composed of the rails. When the first pair of wheels of a train comes onto the circuit rails, it makes a short circuit and the latch drops into the slot and locks the lever until the last pair of wheels passes out of the circuit, when, the circuit being restored, the latch is lifted out and the lever released. This has never come into general use, as it causes too much delay to traffic.

LOAD ON EACH LEVER.

In England a separate lever is used for each signal, switch, etc. This makes very large interlocking machines and costs more than is necessary. In order to reduce the expense and the size of the machines, appliances have been introduced by means of which one lever is enabled to work two or three switches, locks, and bars, or four or five signals. This practice has been carried to an extreme, for while the first cost of an interlocking plant may in this way be decreased, its maintenance may be made very much more, and as the latter is the expense that runs through time it is more important than the first cost. As a result, we are now trying to strike a happy medium in the loads on the levers. Two of the mechanical devices arranged for this purpose are very ingenious: 1. The double point switch and lock movement, which enables you to throw a switch, lock and detector bar with one stroke of the lever, and, 2, the selector box through which a number of signals can be individually and singly operated by one lever.

1. DOUBLE POINT SWITCH AND LOCK MOVEMENT.

This has a double sliding bar, B (Fig. 14), the two halves of which are fastened at the ends with a space of 1½ inches between them and arranged with friction rollers; in the center of this bar there is a stud extending from one side to the other, with a roller on it. Placed on the same bed plate is an open bell crank, C, that is, one end of the crank is split and looks like the jaws of an alligator wrench; the switch rod is attached to the ordinary end of this crank, while the stud on the sliding bar works through the open end. The double sliding bar is connected with the tower and with the detector bar through a three-way bell crank, as shown in the figure. To throw the switch the slide bar is pulled and the detector bar begins to rise above the top of the rail; while the detector bar is coming into this position the switch has not moved, as the stud has been traveling along one side of the open jaw, but when the detector bar gets to its highest position the stud crosses the opening in the jaws and strikes the opposite jaw, pressing it over so that it can slide past; this movement reverses the switch; the stud then travels along on this jaw until the detector bar has dropped below the rail. There is also an arrangement for locking attached to this. On the top of the sliding bar there are two lock pins, DD, about three inches long, one on each side of a slot in the bed plate casting; there is a bar, E, passed through this slot and fastened to the center of a front rod on the switch points; in this bar there are two holes, one, and only one, registering in front of a lock pin after the switch has made a complete throw in either direction. This lock pin passes through the hole in the lock rod while the detector bar is dropping below the rail, and the stud in the sliding bar is traveling on one side of the bell crank jaw. If anything should fall between the switch points and the rail and prevent the switch from making a complete throw, this lock bar would not register in front of a lock pin and the lever could not be latched in the tower. Hence the signal lever could not be thrown, and everything would have to stop until the switch was cleaned out and made safe.

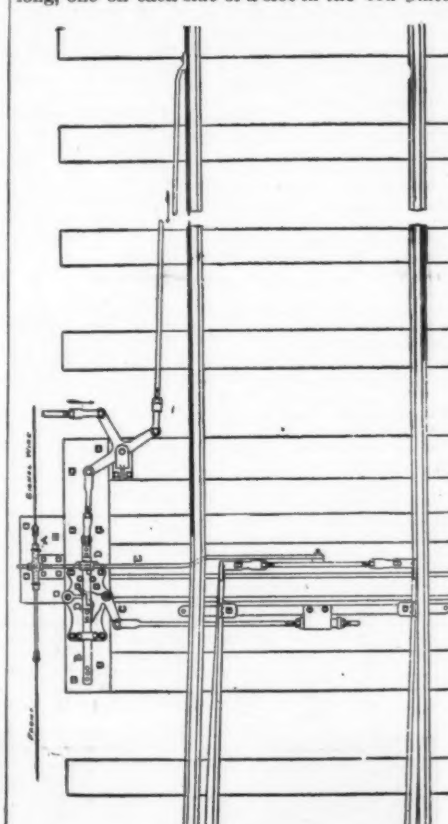


FIG. 14.—Double point switch and lock movement.

WIRE BOLT LOCK.

There is still another lock used in connection with this, called a wire bolt lock. This is a mechanical device placed in the front wire of the signal where it passes the switch points (A, Fig. 14). From the switch points there is a bar run out to this lock with notches cut in it for each position of the switch. If any part of the connections to the switch should break, so that, although the switch would not make a complete throw, the lever would, thereby releasing the signal lever, the signal arm would not come, as the wire would be locked at the switch points.

2. SELECTOR.

The selector is a small interlocking machine in itself,

* From the Bulletin of the University of Wisconsin, No. 6.

From one lever in the interlocking machine there is a pipe connection run to a slide in the selector box; in this box there are a number of arms, one for each signal to be operated, which are connected directly to the signals. These arms are raised or lowered by connections running from the pipe lines to the switches which are to be signaled; the reversing of the switches automatically changing the arms in the box. When a route is set up, all of the arms are held up except the one attached to the particular signal for that route, which is down; and when the signal lever is pulled the slide engages the arm that is down and pulls the signal clear; there is a back wire to each signal which is attached around a wheel to the box, and pulls the signal back to danger. There is no limit to which this can be carried, but it requires careful attention in adjustment or it will cause delay, and more than two way selectors are not advisable.

SLOTTED SIGNALS.

It sometimes happens that two interlocking towers are located so close together that some of the signals are made common to both towers; that is, the clearing of certain signals is made dependent upon the joint action of both sets of operators. This is accomplished through what is known as the mechanical slot (Fig. 15). (There is also an "electric slot" that accomplishes the same purpose.) The mechanical slot is an iron frame which is arranged to slide through a casting fastened to the post below the signal arm. From the top of the frame there is a rod connected to the signal. Running into the bottom of the frame are two arms, the ends of which are beveled toward the center, each of the arms being attached to a separate balance lever. The front and back signal wires are attached to these balance levers, and one set of wires runs to each tower. Resting on the top of the two arms in the frame is an iron disk, which is free to roll from the top of one arm onto the other. This disk is directly under the top of the frame. If one of the arms is pushed up into the frame, it rolls this disk over the top of the other arm and slides past it, but when the second arm is pushed up it cannot roll the disk away, so that it pushes the frame up with it, and this pushes

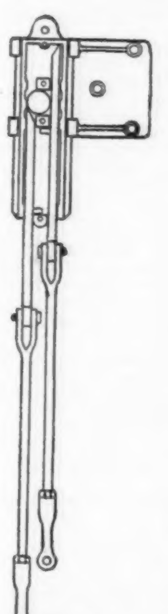


FIG. 15.

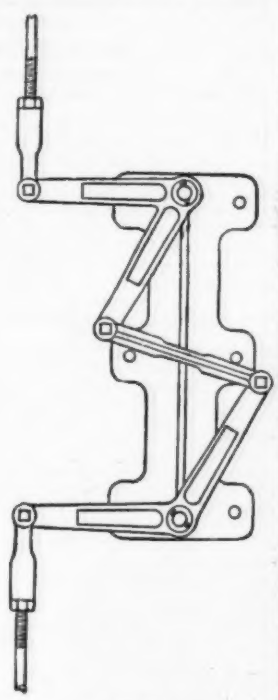


FIG. 16.

the signal clear. Either arm may be first withdrawn, and the first one will throw the signal back to danger.

COMPENSATORS.

One of the first things for the engineer to take into his calculations when using iron or steel for erecting purposes is nature's law of expansion and contraction. A piece of metal will expand or contract in direct ratio to its length for each degree of change in temperature; this must be taken care of in the pipe and wire lines. Pipe lines will expand about 84-100 of an inch in each one hundred feet for each one hundred degrees (F.) increase of temperature. This expansion is taken care of by placing a compensator in each pipe line half way between the tower and switch or signal. This can be done by placing a straight bar, pivoted in the center, on a suitable foundation, and connecting half of the pipe line that runs to the tower to one end, and the other half of the pipe line that runs to the switch or signal to the other end; as each half will expand or contract equally, the bar will move on its center, and as the end of the pipe line is a fixed point at the machine lever, the switch or signal end must also be a fixed point. This form of compensator has a very serious objection, as it throws the connections out of line. To overcome this objection the lazy jack compensator was invented, which accomplishes the same purpose as the straight bar but does not throw the pipe out of line. The lazy jack compensator consists of two bell cranks (Fig. 16), one having an angle of 60 degrees and one an angle of 120 degrees, placed on a suitable bed plate, the two cranks being connected together by a link. The free end of one crank is connected to the line which runs to the tower, and the free end of the other crank is connected to the line which runs to the switch. As the stroke from the lever to the switch is transmitted through the compensators, the motion is reversed; that is, a pull by the lever gives a thrust at the switch, and vice versa. The compensation of pipe lines gives no trouble, but of all the wire compensators so far introduced not one has given satisfaction.

(To be continued.)

BRIGHTON AND ROTTINGDEAN TRAMWAY.

THE following is a brief description of this line, which is now causing a considerable amount of discussion on the Brighton Town Council.

The line commences at the eastern end of the electric railway, Brighton, and extends a distance of three miles to the village of Rottingdean, a favorite summer resort.

Here a small iron pier has been erected for the cars to run alongside; the pier is available for steamer traffic and promenading. At the Brighton end of the line an iron jetty has been erected, and a building containing commodious waiting rooms and offices has been erected on it. The rails are laid on concrete blocks (made in situ) spaced about 3 ft. apart, mortised into the sound rock, the height of the blocks varying with the irregularities of the shore. A shifting sand of very moderate depth covers the rock in places; the rails, however, have been laid sufficiently high to prevent any trouble from accumulations on the rails. The steepest gradient is 1 in 300 and the radius of curves 40 chains.

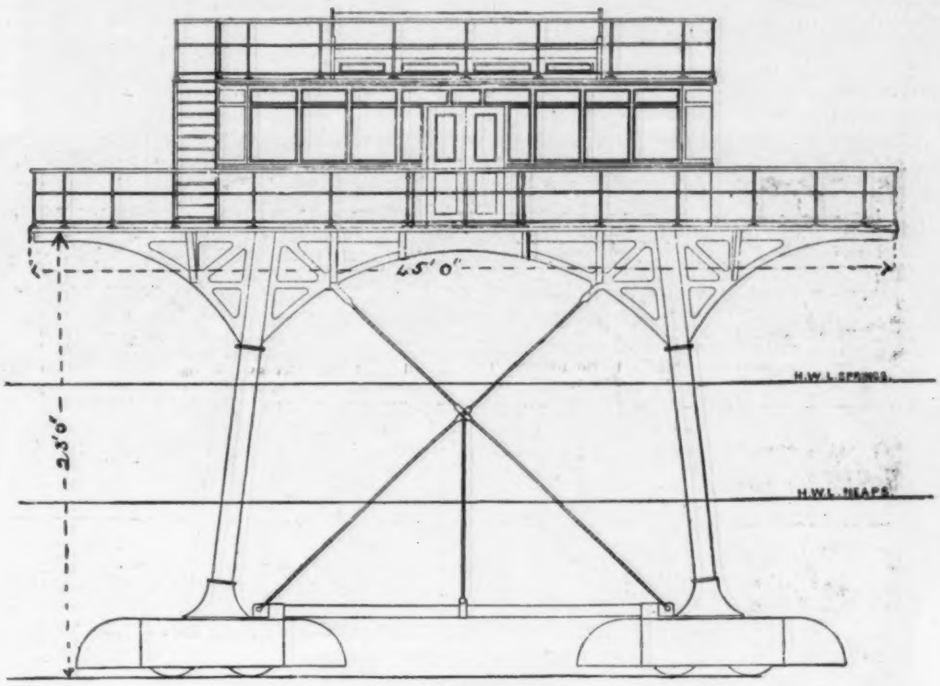
The line consists of four rails (54 lb. per yard) laid as two tracks of 2 ft. 8½ in. in gage, spaced 18 ft. between outer rails, thus giving an effective gage of 18 ft. This is rendered necessary to give the required stability to the cars. The rails are secured by steel clips and bolts, the latter being embedded in concrete; oak blocks, through which the bolts pass, being placed between the rails and the concrete blocks. Tie rods are also used every 10 ft. on the straight and every 5 ft. on the curves; heavy angle fishplates are used for the rail joints; the rails are in 30 ft. lengths.

The depth of water over the rails at high tide is about 15 ft. Although the most violent gales experienced for many years occurred during the winter of 1894-95, no damage whatever was done to the permanent way; so the fact that it possesses ample strength to resist the force of the sea has been demonstrated in a satisfactory manner, and no accumulation of seaweed, etc., has taken place at any time. The line is now practically completed, but the work, being tidal, has been greatly delayed by bad weather.

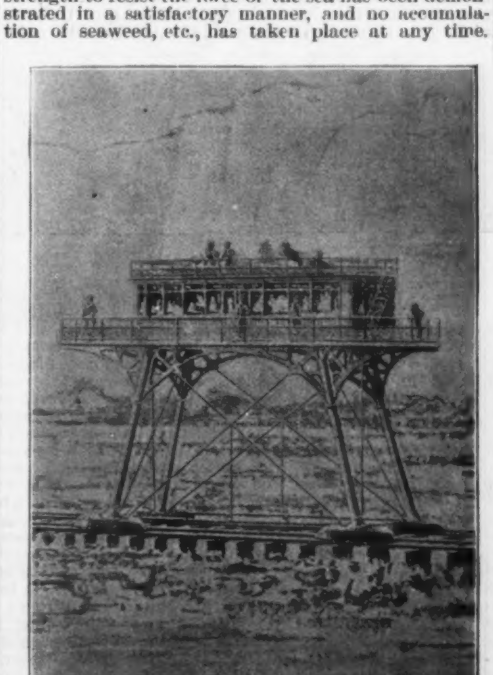
The car, which has been built by the Gloucester Railway Carriage Company, is a structure carried on 16 wheels, 33 in. in diameter. The main deck for the passengers is at a height of 24 ft. above the level of the rails. The four main legs are tubes of drawn steel, 11 in. in diameter. At the bottom of each leg is placed a bogie truck having four wheels, the outside of the bogie being shaped like an inverted double ended boat, to facilitate its passage through the water, and also to remove any obstructions from the rails. The four bogies are firmly held together by steel tubular struts. The wheel base, about 28 ft. long, and the effective gage, 18 ft., give great stability to the car. The tops of the main legs are firmly built into lattice girder work carrying the deck, and the whole structure is firmly secured by cross ties. It is of great strength, although offering but a small surface to the force of the waves. The main deck appurtenances and erections are carried out exactly as if for a steam yacht. The deck measures 50 ft. by 22 ft., the railings round the deck being of iron with a wooden top rail and wire netting. The center space of the deck is occupied by the saloon, a structure 12 ft. wide by 25 ft. long. The roof of the saloon is railed round and forms a promenade deck, seats being placed over the glass dome and over the center of the saloon. On this upper deck will be placed the controlling apparatus for driving and stopping the car. As the journey, in short, will be undertaken more for the sea air than for quickly making the trip, it is proposed to keep the speed between six and eight miles an hour.

The driving machinery will consist of two 30 h.p. electric motors placed vertically over two of the main legs, one on each side of the car, the shafting being carried down inside and communicating with toothed gearing which actuates the wheels. The brakes are worked by rods passing down the remaining two legs.

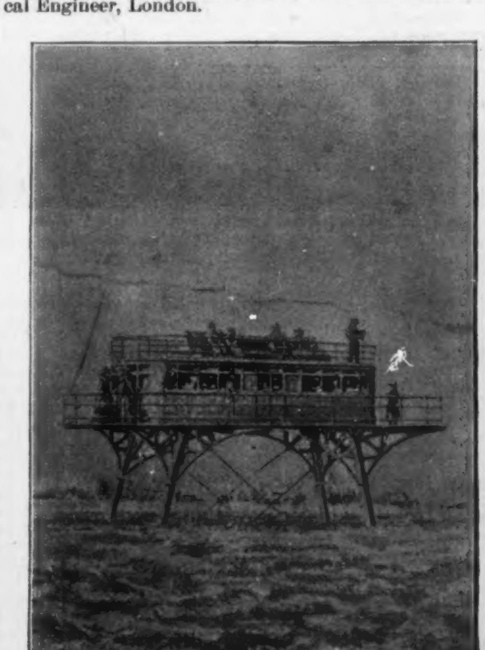
The current, at 500 volts, will be conveyed to the car by means of a trolley pole overhead.—Electrical Engineer, London.



SEASHORE CAR.



AT LOW TIDE.



AT HIGH TIDE.

THE MAKING OF A TUNNEL—THE WATERLOO AND CITY RAILWAY.

THIS railway was commenced in June last year, and will probably be completed by the end of 1896. The entire length of the line will be slightly more than a mile and a half, and the journey will be made in four and a half minutes, and to avoid delay it has been decided to have no intermediate stations. During the busy hours of the day the trains will run with a frequency that will make the time table unnecessary. At the Mansion House Terminus the railway will be reached by a lift, as at that point the tunnels run to a depth of sixty-five feet, but at the Waterloo Terminus this will be dispensed with, and passengers will walk down a gentle decline. The proposed route will run along Stamford Street, on the western side of Blackfriars Bridge. On the Middlesex side of the river it will run almost exactly under Queen Victoria Street, finally terminating a few yards short of the Mansion House.

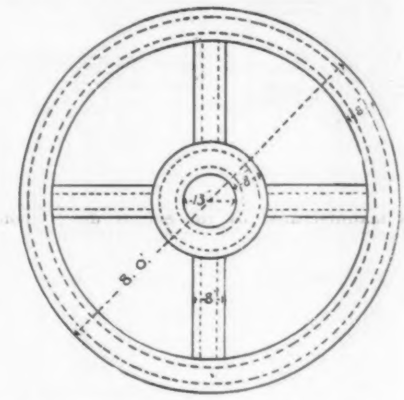
The tunnels are reached by a series of upright ladders running some sixty feet down the sides of the two shafts that connect the subterranean workings with the upper world. Two huge iron cylinders have been sunk deep into the bed of the river close to the Surrey bank, a little west of Blackfriars Bridge, and it is from this spot that the borings are carried forward. There are two tunnels, one for each line, running parallel to one another. From the foot of the shafts the borings are carried as nearly as possible north and south, in one direction crossing the river on the way to the Mansion House and in the other curving round in a westerly direction toward Waterloo. Down the center of either shaft a huge chain hangs idly from the arm of the steam crane until the blast of warning from the miniature electric locomotive announces the arrival of a train of trucks; the bottom of the pit becomes alive with workmen, the great steam crane rattles overhead, and truck after truck is carried bodily i to the air and swings out of sight. One of the greatest difficulties that the engineers have to contend with is the water in the soil that threatens to flood the borings. For the most part the railway runs through London clay, heavy enough to work, but free from water. Lying on the clay, however, there is a stratum of gravel heavily impregnated with water. The simplest and by far the least expensive method of obviating the difficulty would be to allow the water to flow into the borings and pump it out again. Unfortunately this method is not without its attendant dangers. The water flowing into the tunnel would in all probability carry with it a certain quantity of sand, loosening the earth above already burdened with the weight of buildings, and thereby rendering the land liable to a subsidence. No such risks could be incurred, and the act of Parliament which empowered the company to construct the railway forbade this method of procedure. The only alternative, by far more costly and inconvenient, was to keep the water out. This is done by compressing the air in the tunnels at points where indications of water appear. The water-bearing stratum is only encountered on the Surrey side of the river, but the engineers of the Metropolitan Railway Company were of opinion that the boring underneath their line might cause a subsidence, so that the works have to be carried on under compressed air at the point where the tunnels dip under the Metropolitan Railway, close to St. Paul's Station. Within a few minutes' walk of the foot of the shaft through the down tunnel running to Waterloo a solid-looking brick wall bars the way. The wall is six feet thick and on the other side of it the air is compressed. An iron cylinder that looks like the boiler of a locomotive projects from the base of the wall. This is an air lock, through which trucks and men pass on their way to the head of the tunnel. In principle it is identical with water locks such as are used on canals. A door in the end of the cylinder opens inward, and the trucks are passed in. As soon as the door is closed after them compressed air is gradually admitted from the other side by means of valves. The increasing pressure keeps the outer door closed, and when the air in the lock is sufficiently compressed the equalized pressure allows the inner door to be opened. The empty trucks are then passed out through the lock, and presently returned laden with clay. The same process is then repeated. A bell tinkles to show that all is ready, and the workman in charge opens the valve to let the air imprisoned in the lock escape. It comes screaming out through the open valve, sending a draught through the tunnel that can be felt many yards away. Gradually the rush of air diminishes, and the massive iron door is swung easily back on its hinges. Nothing but dense cloud is visible at first, for the operation of diminishing the density of the atmosphere has formed clouds in the lock. By degrees the vapors pass away, and the laden trucks come into view. The workmen drag them out and hitch them on to the locomotive; the horn bellows and the miniature train rattles away. The up tunnel leaves the Waterloo Terminus at a steeper gradient, and dipping sharply down under the water bearing stratum, it runs through the clay underneath, thereby obviating the necessity of compressed air. In the case of the down tunnel this is not feasible, as it has been found inadvisable to run a train up a steeper gradient than one in sixty—that is to say, the track should not rise more than one foot in sixty feet of line.

THE CITY AND WATERLOO RAILWAY TUNNEL, LONDON.

In the lower boring the men are cutting their way through the stiff soil without the precaution of compressed air. The work goes on unceasingly day and night, for but few men can work at once, and the progress is necessarily slow. In twenty-four hours the great iron shield in which the men labor moves ten feet forward.* Every inch is cut with the pick through the solid, endless wall of clay One of the miners bores some feet in advance, cutting a small square-shaped hole, which another enlarges and makes round. The miners are assisted by laborers, whose duty it is to shovel away the loose earth. The rough edges left by the picks are finally planed down by the shield, which is forced forward by hydraulic rams. The inside of the tunnel is coated with huge flat rings of iron bolted securely together. Each ring covers twenty inches, and these are finally covered with concrete. When the shield has advanced sufficiently, the rams are drawn back and another ring is built. A scaffold is erected and the men fix the ponderous segments of the ring in the roof. Wedges and bolts are driven into position with sledge hammers that the men swing upward, striking with marvelous accuracy. As soon as the last blow has been struck and the last nut turned the scaffolding disappears like a pontoon bridge, and the work of clearing away the debris begins afresh. The miners advance another two feet, the rams are set in motion, and another ring erected. Each iron segment has a hole in the middle through which blue lias lime is driven by means of compressed air. This fills up the annular space left by the advancing shield between the ring and the earth. The lime sets hard, forming a firm foundation.—The Graphic, London.

A NOVEL BRICK CHIMNEY.

MR. D. J. CURTIS, of Springfield, Mass., had built for him about a year ago at his brickyard in Chicopee, Mass., a brick chimney, which is really a novelty in its construction and, what is more, has proved a complete success. The following brief description of this chimney will undoubtedly be of interest to those who desire a better draught for their furnaces, but cannot afford a high priced stack.



PLAN OF CHIMNEY AT GROUND
DOTTED LINES SHOW 4 IN WALLS
0 1 2 3 4 5
SCALE OF FEET

Mr. Curtis' plant is situated in the midst of a rich clay bank and in a spot convenient to his boiler. He made one excavation 8 feet deep and 8 feet square.

On the bottom of this pit he placed a layer of 2 inch oak plank, and on top of these he laid another layer of the same material crosswise.

For the inside flue he turned a circular wall of brick 13 inches in diameter on the inside and 8 inches thick. Outside of this he turned another and larger circle 8 feet in diameter on the outside and 8 inches thick. These two walls he connected by four arms or braces, as seen in the illustration, which were also 8 inches thick and were bonded into the circular walls every three or four courses.

These walls were run up plumb to the top of the ground, or about 7 feet, where he changed his 8 inch walls for 4 inch, starting them exactly in the center of the 8 inch walls. Incredible as it may seem, he ran these 4 inch walls up 72 feet, where the batter of the outside caused the two walls to come together.

On top of this a cap or head was put on 8 feet high, which made the total height of the stack 80 feet above the level of the ground. The chimney above the level of the ground was built of circular brick, which were easier to lay and made a better job.

In the construction of this stack Mr. Curtis used only the best and hardest brick, and, above all, he took particular pains to see that the bricks were well wet before being placed in the wall. From the bottom of the chimney to the head he used only the best cement mortar, and for this purpose he consumed 35 barrels of Rosendale cement. The head was laid up with Portland cement mortar, which required 6 barrels of Portland cement.

The number of brick used in the chimney was a lit-

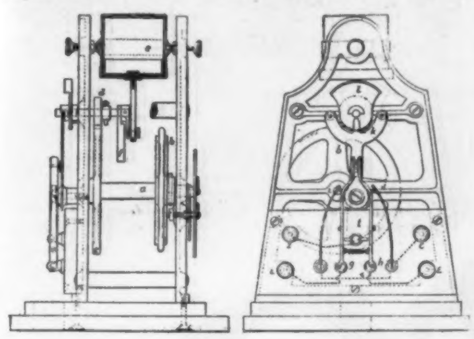
* The shield here mentioned is the well known Beach Hydraulic Shield, an American invention, now generally used by engineers in tunneling through earth. The Beach Shield was used in constructing the great Blackwall tunnel, 27 feet diameter, under the Thames; also used in the Glasgow and Edinburgh tunnels.

the less than 25,000, and the mason laid these for about $4 per thousand. Counting the brick at $125, labor $100, cement $60, sand, planking and cost of excavating $30, we have the total cost of an 80 foot brick stack, $315.

It is the accepted theory, we believe, that the core or inside lining of a chimney should be left entirely free from the outside, as the intense heat brings about an expansion and contraction of the walls, which is apt to make serious cracks in them. But Mr. Curtis' experiment seems to have upset all these theories, as this stack has been used with intense heat for about a year, and it stands to-day as solid and firm as the day it was built. Mr. Curtis will be glad to exhibit his chimney to any one interested, and will try to convince all comers that his idea is practical and economical as well. It is certainly a radical deviation from the usual method.—The Brickbuilder.

ELECTRIC REGISTERING WATER LEVEL INDICATOR.

IN hydraulic installations of some size, comprising water reservoirs remote from the source of supply, it is indispensable to know in a precise manner the variations that occur in their level, in order that the



FIGS. 1 AND 2.—TRANSMITTER OF THE WATER LEVEL INDICATOR.

superintendent of the service may at all times be kept informed as to the state of affairs and know when he must cut off or turn on the feed water.

Under such circumstances, electricity renders useful services for the transmission of acoustic or optical signals to a distance. The city of Paris employs the Parenthou indicator, which gives a signal every time a definite variation in level occurs in the feed reservoirs; for example, a variation of two inches one way or the other. In Germany, the Siemens and Halske indicator has been successfully applied.

In Switzerland, we find a similar apparatus, which is manufactured by the Société des Telephones, of Zurich. The India Rubber, Gutta Percha and Telegraph Works Company has recently elaborated and applied for the same purpose a registering indicator that is as yet but little known, and a description of which we think will interest our readers. Like the Parenthou indicator, it gives a signal every time that a positive or negative variation of some importance occurs in the level of a reservoir, and, like all apparatus of the kind, comprises a transmitter and a reservoir. The former is placed above the reservoir, and is

FIG. 3.—GENERAL VIEW OF THE TRANSMITTING APPARATUS.

represented in Figs. 1 and 2. It carries a float which follows the level to be registered and the suspension chain of which passes over a pulley, b, keyed upon the shaft, a, of the toothed wheel, c. The latter gears with a pinion, d, loose upon its axis, but carrying laterally a pin that can be carried along by a sleeve keyed to such axis and provided with two tappets that are placed diametrically opposite each other. To one of the extremities of the axis is fixed a crank connected with a piston, e, whose cylinder is mounted upon supports between the cheeks of the apparatus, and the object of which is to prevent the transmission of any motion due to a variation of level. Behind the crank of this transmitter there is a piece, f, formed of a counterpoised lever oscillating freely upon its axis, but with which it may be connected by two catches, one or the other of which carries along the counterpoise according to the direction of rotation of the shaft. Finally, outside of the frame there is fixed upon the axis a cam, l, that acts upon electric contacts, by means of which the motions of the float are transmitted to the receiving apparatus, which may be located at a great distance from the reservoir and consist of a simple dial accompanied or not with a registering device.

In the operation the float causes the revolution of the pulley, b, which in its turn actuates the pinion, d, through the wheel, c. This pinion is capable in the first place of moving in an angle of 180° without carrying along its shaft, which it afterward forces to revolve as soon as one of the tappets of the sleeve is met with by the pin of the pinion. Then the counterpoise, f, is lifted by one of its catches until it occupies its upper position. Every ulterior displacement has the effect of causing it to fall again on the opposite side,

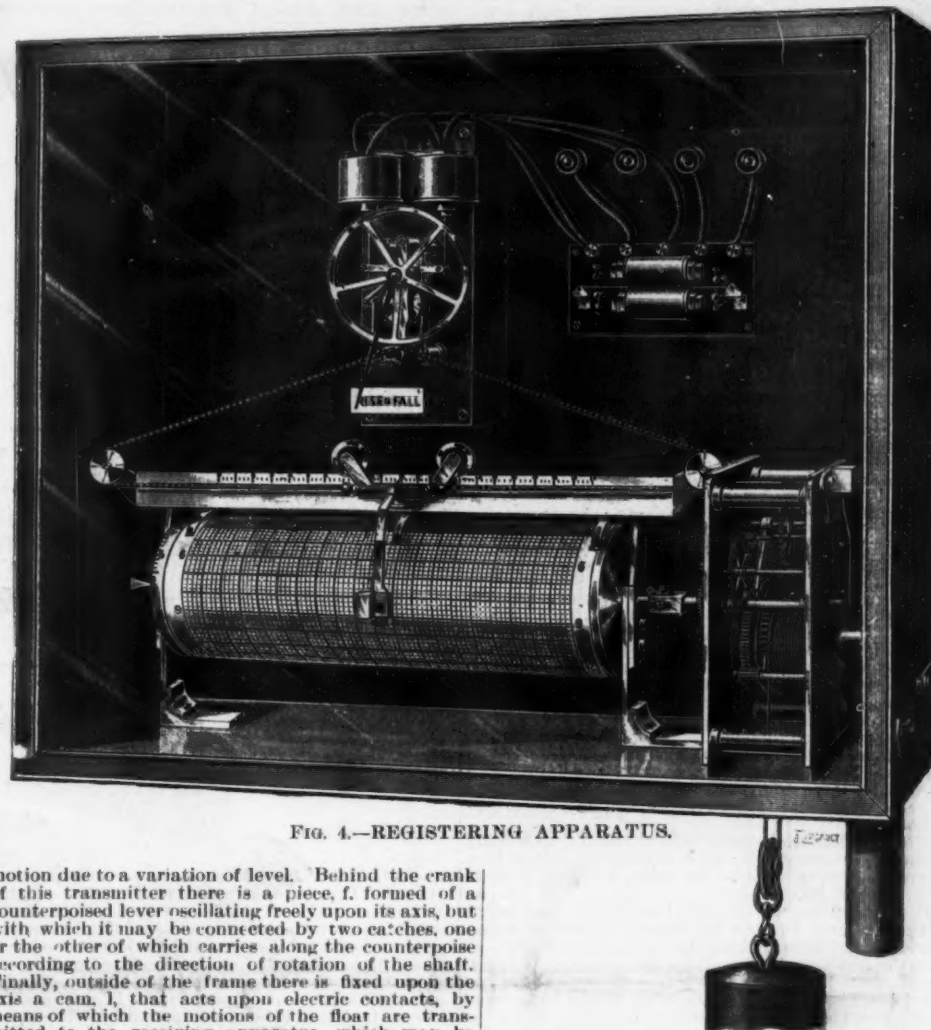


FIG. 4.—REGISTERING APPARATUS.

and by this means it carries along the shaft, which, as we have said, is loose in the pinion, d.

The counterpoise thus comes to rest in its lowest position, but during its fall it has caused the revolution, by an angle of nearly 180°, of its shaft, which, through the double cam, l, produces an electric contact in the course of this reversal and sends a signal to the engine room. This contact begins to take place at the beginning of the fall of the counterpoise, and is broken before the latter reaches its lower position. Owing to the use of the deadener, e, it is sufficiently prolonged to produce a clear and precise signal in the receiver at the other end of the line. Besides, according to the direction of the fall of the counterpoise, the current transmitted is positive or negative. The arrangements of contact are clearly shown in Fig. 2; with the terminals, L and E, of the line wire are respectively connected the rods, g and h.

On another hand, the copper and zinc poles of the line battery situated toward the reservoir end in the terminals, C and Z, the first of which is connected with the elastic strips, i and j, which are usually remote from the rods, o and h, while the second is connected with a crosspiece, t, with which the rods, g and h, are held in contact by a traction spring placed between them.

Toward the top these latter inflect and tend to touch each other but are prevented from so doing through the interposition of an ivory pin inserted in the lower extremity of the jointed lever, k, that forms a fork upon the branches of which acts the double cam, l. When this latter revolves it causes an oscillation of the lever, k, which, according to the direction of its motion, thrusts, through its ivory pin, one or the other of the rods, g and h, and causes it to quit the contact of the crosspiece, t, connected with the zinc of the battery. This initial phase of the operation is effected by the central part of the cam while the counterpoise is raised. In the second place, when, through its fall, the latter completes a revolution around its axis, the external part of the cam enters into play and displaces the lever, k, in such a way as to bring that one of the two levers, g or h, that no longer touches the crosspiece into contact with one or the other of the elastic strips, i or j. At this moment, the circuit of the pile is closed and a signal is transmitted to the receiver.

It results also from the mode of action of the double cam that if the float rises in the reservoir, a current of a certain direction is sent through the line, and that, if it descends, a current of contrary direction is emitted. The pencil of a registering apparatus or the hand of a dial then moves in a corresponding manner.

The graduations of the dial usually correspond to a change of level of three inches, and, in totality, to a difference of level of one hundred feet. They should be of such a number that, at a maximum level, the hand shall not return to zero and introduce confusion into the indication of rise or fall.

This receiver is provided with a pair of electro-magnets whose armatures carry two clicks each—one of

them for engaging with a ratchet wheel and the other to keep it at rest. As the two electro-magnets are placed upon the line, the current emitted, traversing both at the same time, would tend to raise the clicks on each side of the wheel, so that no displacement would occur; but the arrangements employed are such that the current renders one of the electro-magnets active for an elevation of the water level, while the second acts only in case of the lowering of such level. This result is obtained by means of a polarized relay supplied by a local battery and combined with a contact that puts in short circuit one or the other of the two electro-magnets, according as the current sent into its spirals is positive or negative.

Under this form the apparatus is simply an indicator; but the importance of its applications often justifies the use of the registering apparatus shown in Fig. 4.

It will be seen that the mechanism, acting upon a band, actuates also, through an endless chain, a traveler, whose central index indicates upon a scale the extent of the changes of level and carries a pencil that inscribes them upon a sheet of paper, which winds around a drum that makes one revolution in twenty-four hours, thro gh a clockwork movement wound up once a week. This registering apparatus is so constructed as to show a total change of level of one hundred and eighty feet by fractions of one inch.

In the installations of this apparatus, it is well to place the float (which is of wood or tinned copper) not freely upon the water of the reservoir, but in a communicating pipe, so as to protect it against external influences, especially against the action of the wind.—Revue Industrielle.

[Continued from SUPPLEMENT, No. 1041, page 16640.]

NOTES ON GOLD MILLING IN CALIFORNIA.*

By ED. B. PRESTON.

MILL DETAILS.

THE grizzly is a coarse screen consisting of a number of parallel bars attached to a frame, set on an angle from 45° to 55°, over the ore bin. These bars may be of round, rectangular, or V-shaped (apex down) iron, or of wood, faced with iron, and resting on several iron cross rods, held apart with iron washers; the distance between the bars should be equal to the opening the rock crusher jaws are set to—from 2 in. to 3 in. There are no fixed dimensions of length or breadth, as these depend in a measure on local conditions; but they are usually from 3 ft. to 6 ft. wide, and long enough (12 ft. to 15 ft.) to give the fine material time to drop through the spaces before reaching the crusher floor.

Where substantial steel T rails are used for tracking in the mine, they can be made to serve for grizzly bars when no longer of use in the mine, by turning them with the base up.

The grizzly should be placed at the highest point of the mill over the ore bin, where the car or wagon can enter and dump. Its chief object is to separate at once the finely divided ore from the coarser; a secondary purpose is served in affording an opportunity to recover drills, gads, or hammers that may have come from the mine, in the ore, before they reach the rock breaker or mortar. Its lower end rests on a platform in front of the rock crusher, or better, in a chute with an adjustable end gate placed above the mouth of the rock crusher so as to permit of its being fed automatically.

Where the ore as delivered from the mine carries less than 5 per cent. of fine stuff, the grizzly should be dispensed with, especially where, in constructing the mill, fall must be economized. Some object to the use of the grizzly, as tending to feed all the hard rock by itself, and say the output of those batteries is below the others.

Rock breakers or crushers are placed on a platform below the grizzly and above the ore bin in such a manner that the crushed rock mingles with the fine stuff passing between the bars of the grizzly. The rock breaker must be of sufficient weight to remain firm in its place, and strong enough to resist heavy strains; the dies should be easy to exchange and adjust, and all parts requiring to be oiled should be arranged to prevent oil coming in contact with the quartz. In large mills it is best to have one crusher to supply every twenty stamps, and on account of their intermittent work, they should have driving power separate from that of the stamps.

Rock breakers are adjusted to crush the rock smaller than the throat of the mortar (therefore, less than 3 in.), but as the work of the rock breaker is cheaper than that of the stamp, it would pay, with very hard rock, to do more of the crushing with this machine, even to the extent of placing two crushers, one beneath the other, and bringing the quartz greatly reduced to the stamps.

There are two general types of rock crushers. The older pattern carries a flat, fixed jaw, working with one having a reciprocating motion and using flat or corrugated dies that are reversible. The Blake is representative of this pattern. The other pattern has an outer, circular, fixed jaw, within which a corrugated jaw circles, of which the Gates is representative. This latter machine permits of larger blocks being fed. It is an excellent machine for heavy work, and where the rock is not wet or clayey; but it requires greater horse power, for where a Blake, 10 in. by 8 in., crushing 3 tons per hour, requires 9 horse power, the Gates, with a diameter of 37½ in., crushing 3¼ tons per hour, requires 16 horse power. The Gates consists of a nearly vertical shaft of forged steel, rotated from below by a beveled wheel set ⅛ in. out of center, on the top of which a chilled iron conical head is attached, with the base downward, rotating within chilled iron concaves, with an outward slope, set in the cylindrical body of the machine. Between these two faces the ore is crushed, their distance apart below being gaged by set screws. The shaft, by being made to revolve around an eccentric at the bottom, has a constant crushing power without doing any grinding. A set of concaves lasts two years, and can be replaced; the center shaft with the chilled iron head has been known to crush 120,000 tons of an average hard quartz before wearing out.

Ore bins should always be as spacious as the surroundings permit, but never of less capacity than will carry a twenty-four hours' supply for the mill, say about 65 cu. ft. to the stamp. They are usually constructed with a sloping bottom, to facilitate discharging, but where very large bins can be erected this feature is not essential. These bottoms must be solidly braced and ought to be covered with iron plates over those portions where the ore has to be dropped. The front of the bin is parallel with the mortars and supplied with gates for each battery above the level of the hopper of the self-feeders. These gates should be regulated by a pinion and rack, and set for a regular discharge and delivery, through chutes, into the self-feeders. The chutes should be lined with heavy sheet iron.

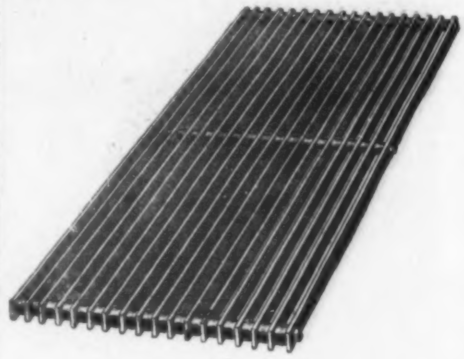


FIG. 10. GRIZZLIES.

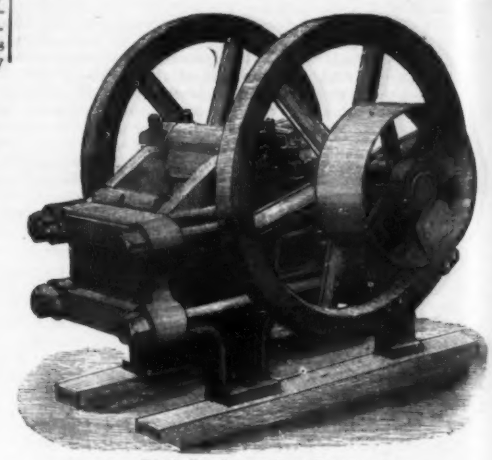


FIG. 11 ROCK-BREAKER, BLAKE PATTERN.

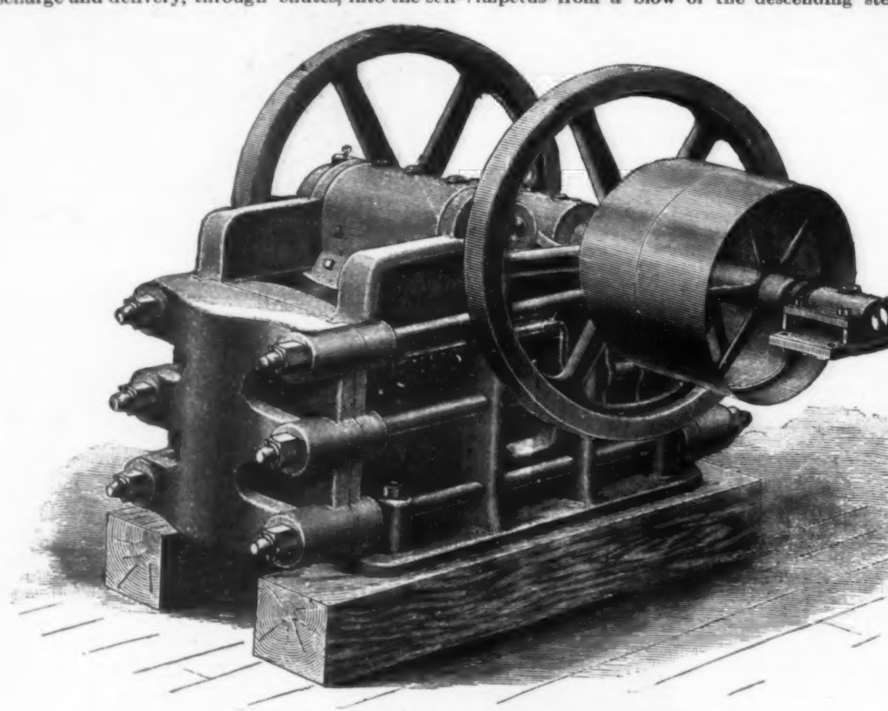


FIG. 12. ROCK BREAKER, BLAKE PATTERN.

Self-feeders.—The entire value of the stamp battery hinges on a regular and even feeding, and as it can be done much better (from 15 per cent to 20 per cent.) by a machine than by hand, this latter method has become well nigh extinct in California. Among the mechanical feeders mostly used are the Challenge (in two patterns), Tulloch, Stanford, and Roller feeders. Although the latter three are very serviceable for certain classes of ore, and are cheaper in first cost, the Challenge is undoubtedly the best all-round machine, which is proved by its almost universal adoption. They are either placed on a frame which runs on an iron track in the feed floor, back of and at right angles to the battery, or are suspended from tracks supported by the battery posts and standards placed against the ore bin. This latter pattern permits of greater accessibility to the feed side of the mortar. In general, the Challenge feeders consist of a hopper with a movable circular plate beneath set slightly inclined toward the mortar, receiving a rotary motion by means of gear wheels acting on the lower face of the plate, which are moved by a friction grip that receives its impetus from a blow of the descending stem on a bumper rod connected with it. Movable wings extending from the point of the hopper over the plate toward the throat of the mortar permit a given quantity of the ore to be scraped off at each blow through a partial rotation of the plate. The older machines were made with right or left handed bumpers, but the present and better plan is to place the rod in the center, so that the third stamp in a five-stamp battery imparts the blow. The newest machines have no bumper rod, but are worked by a collar fastened on the stem above the top of the mortar. Each battery is supplied with its own self-feeder.

FIG. 13. GATES' ROCK-BREAKER.

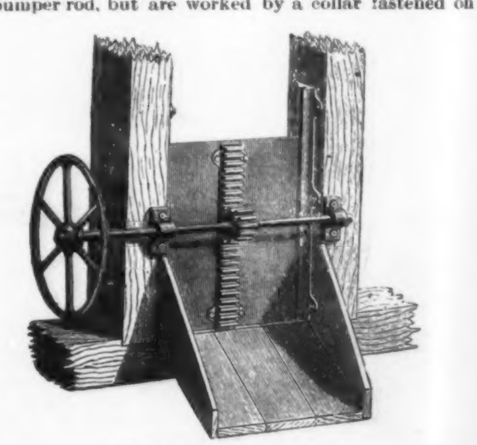


FIG. 14 ORE-BIN GATE.

The Tulloch feeder consists of a square frame, into which a hopper fits, having below a tray suspended from the frame at any desired angle and in such a manner as to have a forward and backward swinging motion inside the frame, which can be arrested on the

* From Bulletin No. 6 of the California State Mining Bureau. J. J. Crawford, State Mineralogist.

forward motion at a certain point by lugs, underneath the tray, striking a bar. The back of the hopper is supplied with an adjustable scraper, and at each motion of the tray a certain amount of the ore is scraped forward and falls into the battery. The machine is operated by the descent of the stamp.

Mortars.—The mortars in California are mostly single discharge, and cast in one piece, extremely solid. When required in places inaccessible by wagon roads, they are cast in pieces, which are later bolted together.

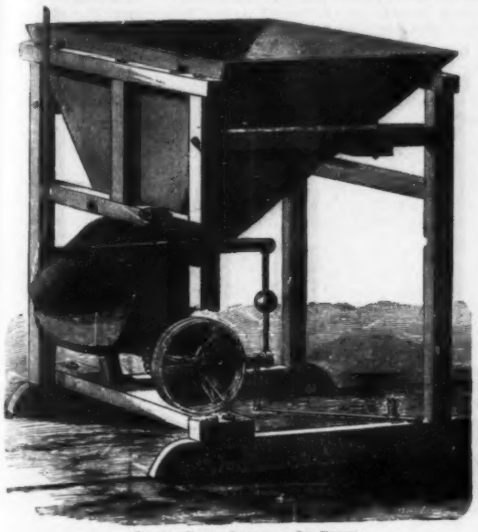


FIG. 15. HENDY CHALLENGE ORE-FEEDER.

Their interior form depends on the nature of the ore and the procedure to be applied. Thus we find them made with narrow or flaring, deep or shallow troughs, and with or without inside plates. Mortars with narrow troughs are made for greater output, while a wide trough assists battery amalgamation and gives opportunity for placing inside copper plates. In some of the newest styles of mortars a series of grooves are furnished in the lining plates to contain quicksilver. The mortars weigh from 4,000 to 6,500 lb., the bottom

FIG. 16. TULLOCH AUTOMATIC ORE-FEEDER.

being made extra heavy; in some of the latest patterns the bottoms are 8 inches thick. The length varies between 4½ feet and 5 feet, and the height from 4½ feet to 4¾ feet. The inside width of the trough corresponds with that of the foot plate of the dies. A heavy flange, 4 × 3 inches, is cast on the base of the

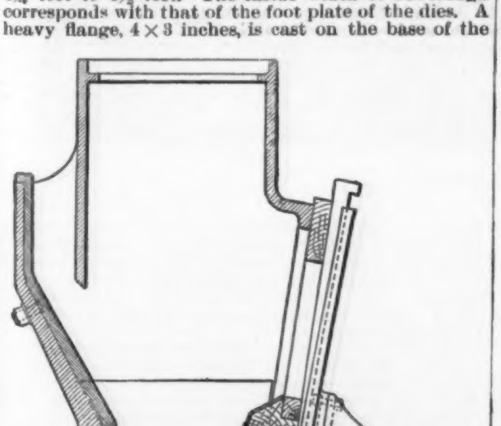


FIG. 17. HAYWARD MORTAR.

long sides, in which are four holes on each side for bolts to secure the mortar to the block.

The difference in design hinges chiefly on the different opinions of leading mining men as to the method and value of amalgamating inside the battery.

Fig. 17, known as the Hayward mortar, is a full-lined mortar, with flaring trough, weighing, complete, about 6,500 lb., without any special arrangements for inside amalgamation.

Fig. 18, the Alaska mortar, is a full-lined mortar, with flaring trough, in which the linings are furnished with grooves to contain quicksilver.

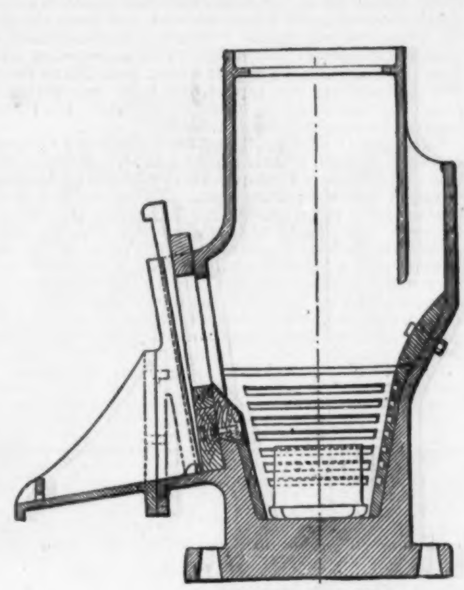


FIG. 18. ALASKA MORTAR.

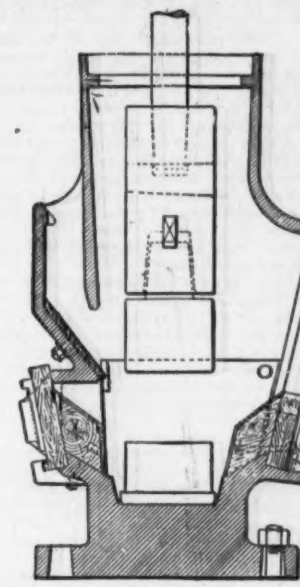


FIG. 19. WILMAN'S MORTAR.

Fig. 19, the Wilman's mortar, was the first attempt at inside amalgamation, using an inside removable copper plate, but this failed to work well; the copper plate, being so close to the shoe and die, scoured and could not retain the amalgam. In remedying this defect, the Pacific mortar (Fig. 20) was produced, in

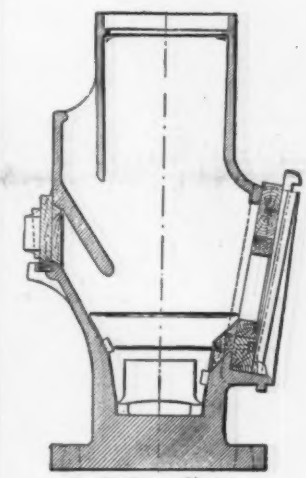


FIG. 20. PACIFIC MORTAR.

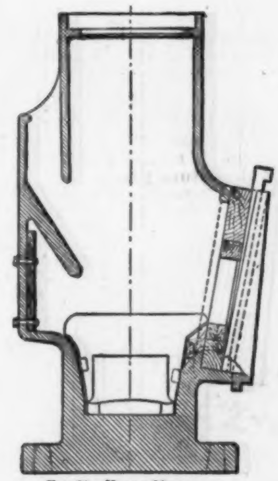


FIG. 21. UNION MORTAR.

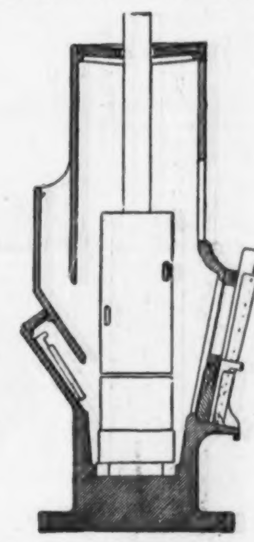


FIG. 22.

which the copper plate was placed higher up under the feed throat; experience in the working of which, suggested changes that finally evolved the Union mortar (Fig. 21) which is provided with a copper amalgamating plate, 12 × 48 inches, bolted in a recess at the back of the mortar, reaching below the level of the

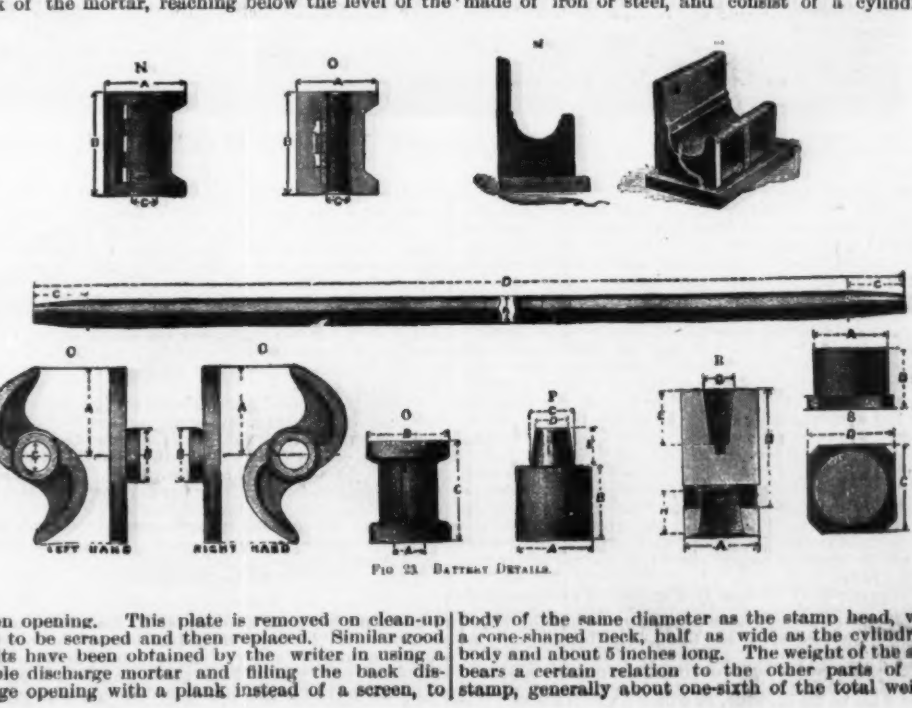


FIG 23. BATTERY DETAILS.

screen opening. This plate is removed on clean-up days to be scraped and then replaced. Similar good results have been obtained by the writer in using a double discharge mortar and filling the back discharge opening with a plank instead of a screen, to which a plate, 8 inches wide and the length of the opening, had been attached.

A modification of this back plate arrangement is shown in the accompanying drawing (Fig. 22) of a mortar designed in Milwaukee, Wis. Here the back plate is accessible, from the back of the mortar, through a covered opening; it is secured in place by a dovetailed key at each end, allowing it to be adjusted to the varying height of the dies.

Dies (see K, Fig. 8, and S, Fig. 23).—They consist of a cylindrical body of the same diameter as the shoe, with a square foot plate with broken corners, and should fit loosely against the front and back plates of the mortar. The broken corners permit their easy removal. They are cast both in iron and steel.

Shoes (see J, Fig. 8, and P, Fig. 23).—They are made of iron or steel, and consist of a cylindrical body of the same diameter as the stamp head, with a cone-shaped neck, half as wide as the cylindrical body and about 5 inches long. The weight of the shoe bears a certain relation to the other parts of the stamp, generally about one-sixth of the total weight

when made of chrome steel, but somewhat less when made of iron. The cylindrical portion of the shoe is somewhat longer than the corresponding part of the die, on account of its greater wear—the latter being protected by a cushion of quartz. Both shoe and die are used until worn as thin as possible; with the shoe this may be one half inch, though rarely, while the die is worn to the foot plate, if not fractured previously. This practice is not to be commended, and should only occur in case of necessity. On stamps weighing about 900 lb. the shoes, if of chrome steel, weigh about 150 lb., and if of iron, weigh about 20 lb. less, and are about 9 inches in diameter. The life of the shoes depends on the nature of the quartz and the height and speed of the drop, but as a general rule shoes and dies of steel last as long as two and a half sets of iron ones, and cost twice as much. In the matter of choice between steel and iron, the vicinity of the mill to foundries is of consequence. Steel shoes and good iron dies usually work very smooth, but where the waste iron can be disposed of at a foundry, this metal is preferred for both.

Stamp Heads, Bosses or Sockets (see J, Fig. 8, and R, Fig. 23).—They are made of cast iron or steel, of the same diameter as the cylindrical part of the shoes and dies, with two conical sockets; the upper one accurately bored out to contain the tapering end of the stem, and the lower one to receive the neck or shank of the shoe with its inclosing circle of thin wooden wedges. Transverse, rectangular keyways, at right angles to each other, pass through the stamp head at the end of the conical openings, connecting therewith in such a manner that when both stem and shoe are attached to the boss they protrude into the keyways. This enables them to be forced out by the driving in of a wedge-shaped steel drift about 1 inch wide, 18 inches long, and tapering down from 2 inches toward the point. The ends of the stamp head are usually reinforced by having iron bands shrunk onto them.

Stems (see I, Fig. 8, and D, Fig. 23).—They are made of wrought iron or soft steel, turned perfectly true, and tapered at both ends for a distance of 6 in. or 8 in. They are from 11 ft. to 14 ft. in length, the diameter varying with the weight of the stamp from $2\frac{7}{8}$ in. to $3\frac{1}{2}$ in. They are reversible, so that if one end breaks, the other end can be used before sending to the shop for repairs. When this repair is made, the whole stem should be annealed. The stem carries the greater weight of any part of the stamp, amounting to nearly one-half. The stems hang in the guides at even distances from center to center, and are supported while at rest by props or fingers catching on the under face of the tappets.

Tappets (see O, N, and O, Fig. 23).—They are made of tough iron or steel, cylindrical, with a flange on both ends, and accurately bored through the center, a shade wider than the stem, and counterbored at both ends; they are provided with a rectangular recess adjoining the central bored hole, 7 in. to 8 in. long and from 2 in. to $2\frac{1}{2}$ in. wide, in which a gib is fitted. This is a piece of wrought iron or steel, grooved on one side, with curvature $\frac{1}{8}$ in. smaller than that of the stem, and planed flat on the opposite side. Two, or in some cases three, slots are cut through the tappet between the flanges, at right angles to the stem, which connect with the rectangular recess for the gib, so that keys, when driven through the slot, press the gib against the stem, which should slide smoothly through the center of the tappet. The tappets are faced on both ends, and are reversible. The keys are of steel, fitted and marked. Tappets weigh from 100 to 120 lb. When fastening the tappet, the keys are driven in solid; but care must be observed, as when too tightly keyed, the tappet is liable to split.

Cams (see C, C, Figs. 8 and 23).—They are of tough cast iron or steel, double armed and strengthened by a hub; which latter is frequently reinforced by having a wrought iron ring shrunk on. The cam itself is the involute of a circle having for its radius the distance between the center of the stem and the cam shaft, somewhat flattened, however, at the point of the cam. It comprises a face from 2 in. to 3 in. wide, ground off, decreasing in thickness from the hub to the point, and strengthened by a rib on the under side, which runs from a point to several inches deep at the hub. The cam is fastened to the cam shaft by steel, hand-fitted keys.

Cam Shafts (see A, Fig. 8).—They are made of wrought iron or soft steel, turned true, with double key seats, 120° apart for cams, besides key seats for the driving pulley. The cams are slipped on the cam shaft with the hub side away from the stem, and keyed solidly in their respective places; they must be placed in such a manner that, when the cams are raising the stamps, the weight is as nearly evenly distributed over the shaft as possible. For this reason proper attention must be given to the sequence in which the stamps are to drop in the battery. Where the shaft is for ten cams, the following order or succession of drops is recommended, viz.: 1, 5, 9, 3, 7—10 6, 2, 8, 4, and would give a drop in each battery as follows; 2, 4, 1, 3 5.

The cam, in picking up a stem on the under side of the tappet, imparts a revolving motion to tappet and stem, requiring from four to six strokes of the cam to complete one entire revolution. A too rapid revolution indicates the need of lubricating. The revolving of the stem assists in giving an even wear to the faces of the shoes and dies, but it does not impart a grinding action to the stamp, as frequently stated, which can be proved by holding a piece of chalk against the stem during its ascent and descent.

(To be continued.)

COLLISIONS BETWEEN STEAMERS AND WHALES.

THE Netherland steamer Waesland, 3,500 tons, which left Antwerp on July 11, 1886, arrived in New York July 27, reported that at noon on the second day a whale was seen floating on the water directly in the vessel's course.

No attempt was made to avoid the animal, as the natural impression was that it would get out of the way of its own accord. It declined to move, however, being fast asleep most likely, and the steamer's sharp iron bows struck full and fair about midway of its length.

There was a perceptible shock to the vessel and an immediate checking of her progress. Passengers and deck hands ran forward to see what was the cause of the trouble and found that the whale was fully 80 feet long, had been cut half way in two and lay dead and fast, caught on the bows.

It was necessary to stop the ship and back off to disengage the carcass, which, when freed, drifted astern.

The steamship Amrum, of Hamburg, Capt. Mundt, came into the port of New York on December 10, 1895, with a tale of a school of whales. The ship got a terrific jolt and a shower of blood from one of the whales, which she ran down and probably killed. After that she got away from the school without unnecessary delay.

The Amrum sailed from Progreso, Mexico, with a cargo of fruit on Nov. 31. It was on Sunday, Dec. 8, when she was off the Florida coast, that she ran into the school of whales. The latitude was 34° 41′ north and longitude 74° 34′ west. It was just at noon that the lookout saw a number of huge black bodies directly ahead. He could see that they were whales, but he thinks they were all asleep, for he watched them for some time without seeing one of them spout. One of them waked up when the steamship got into the bunch and threw out a stream of water in the manner peculiar to sperm whales. Presumably the others were sperm whales also.

The Amrum was now fairly in the midst of them, and the officers were all below, eating dinner, unconscious of the presence of the whales, when there was a shock and a shiver ran through the vessel that made the officers hustle up on deck. They thought the Amrum had banged into a rock that wasn't on the charts. As they reached the deck they saw that it was a seventy foot whale which they had run down. The wounded whale sent up a column of blood and water that fell on the port side of the vessel and drenched the deck from the forerigging to the bridge. Then the whale swung around to the starboard side of the vessel. He poked his head up out of the water and spouted again. This time he was further off and the bloody stream fell back into the ocean. After that the whale sank out of sight.

In the meantime the vessel had been going ahead. While all hands were watching the wounded whale one of the seamen caught sight of another whale, right in the ship's path, and apparently asleep like the others.

"Slow down, slow down!" he shouted.

There was a jingling of bells in the engine room, and

COLLISION BETWEEN STEAMER AND WHALE.

the steamship barely missed the whale. She went near enough to wake him up, if, as the sailors think, he was really asleep. He turned flukes, which means that he threw his tail in the air and dived straight down.

Mate Schlaikier thinks there were twenty good sized whales in the bunch. The collision didn't hurt the steamship.

Ships have struck sleeping whales before. There are also instances where vessels have been attacked by these monsters of the deep and have suffered damage from the collision.

[From the Gardeners' Magazine.]

LECTURE ON POTATOES.*

SPECIES AND VARIETIES.

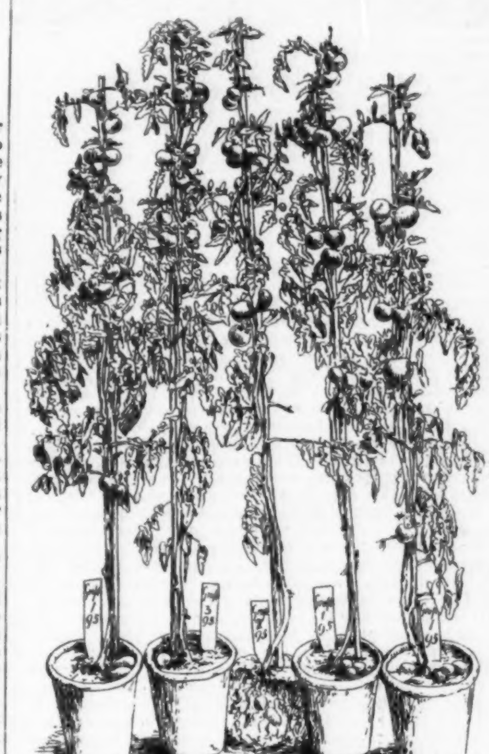
OTHER species and varieties of potatoes of more or less distinct forms and characteristics were referred to and illustrated by lantern slides. The first of these referred to was Solanum etuberosum, grown for many years by Mr. R. Lindsay, in the Edinburgh Botanic Gardens, from whom Mr. Sutton obtained specimens in 1887, which have been cultivated in the Reading Trial Grounds since, with the result that the tubers have considerably increased in size. Mr. Lindsay, writing in 1887, said the original plants had been left in the same beds for at least thirty years; they thus produced long running shoots, having very few and small tubers. Some five or six years ago a few tubers were planted in well manured ground, which has been continued to be done every year since. The results, so far, are that the tubers have gone on increasing in size. No disease has been observed, and they appear when left in the ground all the winter to be quite unaffected by frost. Mr. Baker, in his paper already referred to, speaks of Solanum etuberosum as probably only a variety of Solanum tuberosum, and the lecturer had not noticed anything in this potato either denoting that it was worthy of cultivation on its own account or for crossing with the ordinary Solanum tuberosum, which it seems so nearly to resemble.

The next potato illustrated was the "Papa Amarilla," which had been received from Mr. Charles ap Thomas, who has spent a great part of his life in Peru, and knowing Mr. Sutton took an interest in tracing the history of the cultivated potato, he offered to obtain for him in 1887 a consignment of tubers of the "Papa Amarilla," which is much grown in Peru, and is in some respects unlike our own cultivated varieties. After carefully growing this variety for eight years, there is no doubt that, however suited it is to Peru, it is of no use in this country, where it fails to produce a satisfactory crop, and is not free from disease. Following this a slide representing a potato which a correspondent saw growing in South Africa, and of which he sent tubers, thinking it very different to any he had seen in England, was thrown upon the screen. This has been grown at Reading for seven years, and is distinct from all known potatoes, both in tuber, foliage, and flower. The foliage is exceedingly dark in color, the stems very erect and bushy—growing more densely than any other variety—the leaves are very round, in fact at first sight unlike those of the potato. The tubers are mostly oblong, with the eyes or buds almost as strongly developed as in the Fir apple varieties, and are in color white mottled with purple. It bears a profusion of purple flowers. No disease was observed until 1894, when it suffered badly. Next came a photograph of a potato found growing apparently wild in the Rocky Mountains, by Mr. R. A. Strickland, and sent to Messrs. Sutton through Mr. Hunt, of the Reading Y. M. C. A., in February, 1893. It is almost a counterpart of the large white Fir apple potato, which it resembles both in tubers and foliage. The tubers are often the shape of a spruce fir cone, the eyes being very numerous and deeply set. Much diseased in 1894. The red Fir apple potato, so called from a peculiar formation of the tubers, was shown on the screen. This has been grown at Reading for very many years, and never shows any tendency to assume the form or characteristics of the ordinary potato of commerce. The small white Fir apple has also been grown with the same results at Reading, and differs from the red Fir apple chiefly in color.

The Black Congo potato, illustrated by a slide, has, like the Fir apple varieties, the buds or eyes very strongly developed, and though the flavor is excellent when cooked in the ordinary way, it is chiefly valuable on account of the color of the flesh, which is a dense purple or almost black, rendering it useful for ornamental cookery. A potato grown rather extensively in Norway was referred to, and Commander F. W. E. Crowe, who sent it, considered it extremely valuable for the supply of so-called new potatoes throughout the year, as the tubers seldom are larger than an almond, and by lifting the crop before it is quite ripe the close texture peculiar to new potatoes is retained indefinitely. Three slides were shown representing plants taken from Messrs. Suttons' trial grounds during the past season. Owing to an injury to the stem, the plants were unable to produce tubers below the surface of the ground, and did their utmost to make up for this failure by a vigorous attempt at tuberation from the axils of the leaves. Before referring to Solanum Maglia, which Lord Cathcart selected as possibly the most suitable species for crossing with Solanum tuberosum in order to originate a new race of potatoes which should be more or less disease proof, a spray of Solanum nigrum, a very common weed in some gardens, berries of Solanum Dulcamara, the poisonous "bitter sweet" so often found on hedgerows, and the deadly nightshade (Atropa Belladonna) were thrown on the screen.

HYBRIDIZATION.

With regard to Solanum Maglia, it was said that chiefly on account of the fact that the dreaded potato fungus produces most havoc in damp, wet seasons, it had been very much hoped by Lord Cathcart that if hybrid seedlings could be obtained between the Solanum Maglia (whose habitat was that of low-lying marshy places near the coast of the islands of the Chonus Archipelago) and the Solanum tuberosum, which most writers consider a native of the higher slopes of the Andes, a new race of potatoes might be secured which would resist disease. But it is not at all impossible that Solanum tuberosum may have had its origin as a littoral plant rather than a species of elevated or mountainous regions, which thought is strengthened by the fact that potatoes flourish so amazingly on the warp lands of our eastern seaboard. Although many hundred flowers of Solanum Maglia were artificially fertilized with pollen from cultivated varieties, only five were successful, resulting in five seed berries, and out of these seed berries only two seedlings were secured, and only one of these showed any



TOMATOES GRAFTED ON POTATO ROOTS.

promise whatever, the second requiring to be grown under glass to prevent its dying away. Slides were given illustrative of the foliage, flowers and tubers of Solanum Maglia, and it was stated that last year, in 1894, the crop was almost entirely destroyed by disease out of doors, some indoors being free. A slide was also shown of the hybrid seedling referred to, which, though a vast improvement on the Solanum Maglia, is very far behind the ordinary cultivated potato, both in appearance, crop and qualities. This seed-

POTATO GRAFTED ON TOMATO (WITH TUBERS ON THE STEM).

ling has now been grown for eight years, and in 1894 the crop was slightly diseased. Previously it had almost escaped.

The next few slides illustrated some of the finest seedling potatoes which Messrs. Sutton & Sons have introduced, the crosses having been made in the majority of cases by the late Mr. Clarke, so well known as the raiser of Sutton's Magnum Bonum, and two by Mr. Robert Fenn, one of the oldest and best authorities living on the artificial crossing of potatoes. The varieties shown were Sutton's A1 potato, Sutton's Harbinger, Sutton's Ringleader, Sutton's Windsor Castle, Sutton's Supreme, Sutton's Early Regent, Sutton's Triumph, Sutton's Satisfaction, Sutton's Magnum Bonum, and the Sutton Flourball.

DISEASE PREVENTION.

Reference was next made to the use of the Bouillie Bordelaise as an application for preventing potato disease, and a slide was given showing two plots of Sutton's Magnum Bonum growing side by side during the past season, that on the left hand side having been sprayed three times and that on the right hand not having been sprayed at all. The result was very marked, enabling the plants where sprayed to continue in growth some time after the unsprayed portion had died down, and the difference in the weights of the two plots when lifted was 21 lb.; but, as was to be expected in the case of Magnum Bonum, no diseased tubers were found in either. The question really remained whether the additional weight per acre would compensate the grower for the somewhat laborious task of spraying his crop three times during the growing period. In a most elaborate series of experiments conducted by Mr. Sutton this year, in conjunction with Professor Gilchrist, of the University Extension College, Reading, it was found that in the first and second early varieties there is no advantage from spraying, as these had finished their growth before any disease could attack the plants, and the dressing did not lengthen appreciably the period of growth. Undoubtedly in some sorts which are peculiarly liable to disease, especially when grown in the gardens, a judicious application of Bouillie Bordelaise would secure, even in bad disease years, a crop of sound tubers.

GRAFTING.

Some interesting experiments in grafting the tomato now known as Lycopersicum esculentum, but formerly called Solanum Lycopersicum, were described, and slides given of a bunch of tomato flowers, a bunch of tomatoes and flowers, and Gerarde's illustrations of the tomato plant as known to him in 1597, and the latter was of interest by way of comparison with our present varieties.

A slide was shown representing a tomato and potato graft. One tuber was planted in each pot on March 22, and when about four to five inches high the plant was cut off half an inch from the level of the soil, and a graft of a tomato plant introduced on May 8. The result of this has been that the potato, nourished by the tomato plant above ground, produced a crop of potatoes in the pot, as will be seen in the illustration, and also the tomato plant above ground produced a fairly good crop of tomatoes, nourished by the potato roots in the pot. The next slide showed the same process reversed. The tomato plant was cut off half an inch above the surface and the potato graft introduced. The tomato roots did not, of course, produce potatoes, but the potato plant above ground produced one truss of flowers and seven berries; and in order to extend this somewhat interesting experiment, the tomato flowers have been fertilized with potato pollen and the potato flowers with tomato pollen for further experiment next year. These photographs were taken on August 14; but on examining the plants recently it was found that two of the potatoes growing on tomato stalks appeared suddenly to be aware of the fact that although producing flowers and berries, they had not yet produced tubers, and it being "never too late to mend," they, as was shown by slides, produced tubers from the axils of the leaves and stems.

[Continued from Supplement, No. 1041, page 16634.]

COMMERCIAL FIBERS.*

By D. Morris, C.M.G., M.A., D.Sc., F.L.S., Assistant Director of the Royal Gardens, Kew.

Lecture I.—(Continued.)

CHINA GRASS, RAMIE, OR RHEA.

China grass (Bœhmeria nivea).—This is a shrubby plant with the habit of the common nettle, but without stinging hairs. There are numerous straight shoots that arise from the perennial rootstalk to a height of 4 to 6 feet. The leaves are on long petioles, broadly heart-shaped, with serrated edges and white downy beneath. The seeds are small, and produced somewhat sparingly. This is the original China grass plant so long cultivated by the Chinese under the name of Tchou Ma. It grows moderately well in the south of England, and if the roots are covered in winter, they produce good crops of shoots that are fit to cut in September. In warmer countries, China grass flourishes with great vigor. It is now distributed in most tropical and sub-tropical countries. The China grass fiber usually received in this country has been cleaned by the Chinese by hand. The supply is limited, and no large industry can be sustained by this hand-cleaned fiber alone. When carefully prepared and purified by chemical processes, China grass is pre-eminent among vegetable fibers for strength, fineness and luster. For more than fifty years it has been sought to cultivate the plant and to extract the fiber on a commercial scale. China grass is still, however, in the stage of expectancy. Many inventors claim that they have succeeded in solving the problems connected with it, but no one has yet so thoroughly established his claim as to induce extensive areas to be planted with China grass in any part of the world. Purely experimental plots are common everywhere.

There are two forms of this plant. One is the China grass mentioned above, a temperate, and the other ramie or rhea, a tropical plant, known as Bœhmeria nivea, var. tenacissima. It would be well to preserve these distinctions in regard to the fiber also. The term ramie, or rhea, should only be applied to the variety tenacissima. This differs from the type by its more robust habit and larger leaves, which are green on

* Continued from Supplement, No. 1041, page 16635.

* Lectures before the Society of Arts, London, March, 1895.—From the Journal of the Society.

both sides. This character easily distinguishes it from China grass, which has leaves white felted beneath. The distinction here suggested is an important one. Ramie or rhea is a native of Assam and the Malay Islands. It thrives only in tropical countries, and it is useless to cultivate it elsewhere.

At Kew it has been found that while ramie or rhea (B. nivea, var. tenacissima) cannot be grown in the open air, the China grass (B. nivea) remains in the ground all the winter, and furnishes a good crop of shoots, but only once in the year.

The value of the ramie, or rhea fiber, as compared with China grass, has not been carefully and fully investigated. Ramie from India has, however, not proved so valuable, so far, as the China grass. In the large mass of literature on China grass there is considerable confusion between it and ramie or rhea, and the results in consequence lose their value.

Remarks.—In the plant the bast is a continuous ring, with the cells in loose contact. In a cross section the latter appear ovoid to polygonal, with a large cavity; they are, however, very variable. The mean diameter is greater than in flax. The fiber bundles are usually three in number, frequently single. The cells are of exceptional length; 40 to 200 mm. (1½ to 10 inches). This is greatly in excess of any known fiber.

Cultivation.—Our knowledge of the cultivation of China grass is derived from the Chinese. It can be propagated either by seed or offshoots. Where seed is used, nursery beds carefully prepared, supplied with rich soil, and regularly watered are essential. Care should be taken to mix the fine small seeds of the China grass with soil, and sow lightly on the surface of the ground. The plants raised in these beds may afterward be transplanted, and put out at distances varying from 1½ to 2 feet apart, according to the nature of the soil; the better the soil, the further apart the plants; and, conversely, the poorer the soil, the closer the plants. Clay soils appear to be quite unfit for the cultivation of China grass, and hence these, as also very light, poor, gravelly soils should be avoided. The latter may, of course, be improved by abundant and regular supplies of manure, but the cost of cultivating China grass on such soils would render it prohibitive as an article of export.

When offshoots or suckers can be obtained, they are to be preferred to seeds, as being more expeditious, and yielding better results. When offshoots or suckers cannot be obtained in sufficient numbers, young plants may be obtained by "layering" the taller stems, that is, bending them down (without breaking) close to the ground, and covering the joints with soil. From every ripe joint plants will be produced.

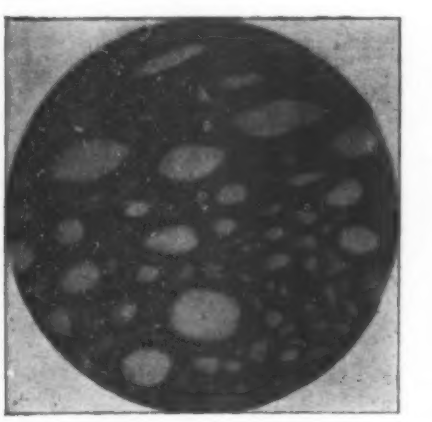


FIG. 4.—CHINA GRASS (BOEHMERIA NIVEA).

Transverse section × 150. The fiber cells are round or oval, with moderately thick walls and large cavities.

The burden of the treatment of the China grass, in all its stages, by the Chinese, is the plentiful use of manure and water. Unless the soil is naturally rich and moist, the cultivators of China grass must be prepared to supply their plants largely with manure, and keep them in a moist, vigorous, perpetual state of growth.

Cutting the Stems.—The shoots are fit to cut when the bark is of a brown color for about six inches from the roots. In the process of cutting, the young shoots springing from the rootstalk should not be injured, as they would form the succeeding crop. When once the China grass plants are established, the stems are produced more abundantly with age, and also grow much faster. Where too thick they should be carefully thinned so as to promote the growth of large healthy unbranched stems. The duration of life of the root depends on the strength and character of the soil, the relative quantity of manure supplied, the amount of moisture present, as well as on the general cultural treatment received by it. There is no reason to doubt that where favorable conditions exist a plantation of China grass will last for many years (ten or twelve), and prove very productive.

The above remarks on the cultivation and cutting of China grass apply equally well to ramie or rhea.

Extracting the Fiber.—In January, 1870, the government of India was so impressed with the value of ramie or rhea as a commercial fiber that it offered a prize of £5,000 for a machine or process that would produce "a ton of fiber of a quality which should average in value not less than £50 in the English market," at a total cost (all processes of manufacture and allowance for wear and tear included) of not more than £15 per ton. A trial of machinery took place at Saharunpur in August, 1872. The prize was not awarded. A donation was however given to one machine, which produced an inferior fiber worth but £18 per ton, and fit only for cordage. In 1877 the offer of a prize was renewed and a further trial took place in September, 1879. The results were equally inconclusive. This offer of a prize by the government of India was definitely withdrawn in 1881. Since 1881 numerous efforts have been made to devise means for extracting the fiber. A process that had some success was the Favier-Fremy process, in which the stalks were steamed and the ribbons or strips were afterward cleaned by chemical means. In 1888 there took place the first of the international competitions held in Paris. The results are given in the "Kew Bulletin," 1888, pp. 273–280. Two machines received a gratuity only. The trials were renewed in connection with the Paris Exposition Universelle in 1889. A report of these is given in the "Kew Bulletin," 1889, pp. 258–278. First prizes were awarded to Mons. P. A. Favier, Société le Ramiè Française, for a mechanical process with rollers, and to Mons. Norbert de Landtsheer, for a machine with a drum and beaters. The former cleaned at the rate of 443 lb. and the latter at the rate of 575 lb. of dry ribbons per day of ten hours, from green stems without leaves. A second prize was awarded to MM. Ch. Crozat de Fleury et A. Moriceau, for a process for steaming the green stems in the fields, and peeling the ribbons by hand. The Favier mechanical process has since been used to extract fiber in France and Spain on a moderately large scale. It is, however, not available for general use, as the inventor prefers to keep it in his own hands.

In 1891, a third series of trials was held at Paris under the auspices of la Société des Agriculture de France. The results were promising, but no practical advance was made on those reported for 1889. In America trials were held at New Orleans under the auspices of the Department of Agriculture, Washington, in 1892 ("Kew Bulletin," 1892, pp. 304–306). These were renewed in October, 1894, and a detailed account is given in the "Bulletin" of the Experimental Stations of Louisiana, No. 32, 1895. "Two machines were entered for trial, one by the Textile Syndicate, 72 Finsbury Pavement, London, for green decortication, and the other by Samuel B. Allison, of New Orleans, for dry decortication." The committee stated: "We report great progress in ramie machines since our last test (in 1892), but neither of the machines are yet ready for successful operation on a small scale by farmers and planters." They added, "the outlook is promising." There are several machines and processes now under experiment in this country, but no public trial has been attempted, owing, probably, to the absence of sufficient material to operate them. It is obvious that such trials can only be properly carried on where there are large areas planted, and where stems are available for continuous working.

Numerous articles have lately appeared respecting a revival of interest in ramie. There is no doubt a large amount of money is being spent in the endeavor to solve the ramie question. Quite recently it was claimed that "the treatment of ramie can now be carried on upon lines that will enable it to take its place among the other textiles . . . . inferior only to silk in point of 'number' or fineness."

What may be regarded as a distinct advance has been made in the treatment of raw ramie ribbons by the Forbes process, now under trial in this country. The filasse produced by this process, forwarded to the Kew Museum, is of exceptional quality. From the Boyle Fiber Syndicate there has been received, for the first time, a complete set of samples of ramie goods manufactured in this country. The yarn was spun at the Long Eaton Mills in Derbyshire. These are quite equal to the best French manufacture. A very complete series of these and similar articles may be seen in the Kew Museum I, Ground Floor, Case 103.

In order to understand the special character of the China grass, or ramie industry, it is desirable to enumerate the different stages connected with it. In the first place, we have the mere business of cultivating the plant, and of producing stems containing the fiber in the best possible condition. This is purely the work of the planter. Secondly, we have the process or processes necessary to separate the fiber from the stems in the form of ribbons and filasse. It is necessary, for many reasons, that this should be done either by the planter on the spot or by a central factory close at hand. Thirdly, we have the purely technical and manufacturing process, in which the filasse is taken up by the spinners, and utilized in the same manner as cotton, flax, and silk are utilized for the purpose of being woven into fabrics.

It may be mentioned that the cultivation of the plants presents no difficulty. They will grow rapidly enough, and, if highly cultivated, will produce two or three, or possibly more, cuttings each year. The chief difficulty is in devising means for extracting the fiber from the stems cheaply and expeditiously. The next stage, for treating the ribbons chemically, and preparing a white "filasse," appears to be much more advanced.

OTHER NETTLE FIBERS.

Besides China grass and ramie, there are many other nettle fibers obtainable from Indian plants that are deserving of notice. It is probable that some of these may be even better than ramie, or at least more readily available for cultivation in certain parts of India. A brief enumeration of the plants yielding these nettle fibers is all that is possible within the limits of these lectures.

Tashiari (Debregeasia hypoleuca).—A large shrub forming dense undergrowths in the Himalayas. The branches and leaves are clothed with a snow white wool. The fiber is extracted by boiling the stalks in water and wood ashes. The fiber is afterward washed, sprinkled with the flour of Paspalum scrobiculatum, and left to dry. It is then ready for spinning. In some parts of India this fiber, on account of its strength, is used for bow strings.

Nilgiri Nettle (Girardinia heterophylla).—A stout tufted herb, rising to 6 feet in height. All parts are covered with stinging hairs. "The bark abounds in fine white glossy silk-like strong fibers" (Roxburgh). The stinging hairs are an obstacle to the utilization of this fiber, but it is undoubtedly of great intrinsic value.

Poi (Maoutia Puya).—A shrubby nettle with leaves white beneath. Dr. Watt reports on this plant: "Probably more easily cultivated than rhea, while the fiber would be found quite as serviceable."

Ban-rhea (Villebrunea integrifolia).—This "wild rhea" of Assam is said to yield a fiber stronger than either China grass or rhea. The plant is cultivated by the native tribes in northeast India, and from it they obtain "a fine fiber, admirably adapted for fishing lines and nets, and remarkable for its power of resisting moisture." It has been recommended to the government of India to cultivate this plant, and investigate its merits side by side with China grass and rhea.

Ban-Surat (Laportea crenulata).—This is a wild nettle of India and Ceylon. It is an evergreen shrub growing in the interior hills, and clothed with stinging hairs. The stems yield a strong useful fiber, suitable for ropes and paper making. Good specimens of the fiber are in the Kew Museum. A sample from Ceylon is labeled "Maoosa" fiber.

Besides these Indian nettles, a few plants, closely allied to them, have come into prominence in other parts of the world:

Urera Fiber (Urera tenax).—A large shrubby or tree-like nettle of Natal, where the bark is highly prized by the natives for the sake of the fiber yielded by it. The fiber is made into thread or cord, and closely resembles China grass, but is rather more brittle, and not so lustrous. This is a comparatively new fiber, first described in the "Kew Bulletin," 1888, pp. 84, 85, with a plate.

Mamaki (Pipturus albidus).—A shrubby nettle of the Pacific islands, especially the Hawaii archipelago. The bark is used for the manufacture of native cloth (similar to that prepared from the paper mulberry—Broussonetia papyrifera). Some fine specimens of fiber and cloth are in the Kew Museum.

Rere (Cypholobus macrocephalus).—This is another shrubby nettle from the Pacific islands, but more widely distributed than the last. The fiber from the bark is made into white fine mats, which in Samoa are "a medium of exchange and a standard of wealth" among the native chiefs.

SUNN HEMP AND SIDA FIBER.

Sunn hemp (Crotalaria juncea).—An annual shrub belonging to the leguminous order, 6 to 10 feet high with bright yellow flowers resembling those of the common broom. It is grown in western and southern India, over an area of 150,000 acres, for the sake of its fiber. This is known as Sunn hemp, Bombay hemp, Madras hemp, and Jubalpur hemp. The stems after being cut are steeped in water until the bark is loosened. The latter is then taken in handfuls and beaten on the surface of the water until the fibrous part is separated and thoroughly washed. The fiber after being dried is cleaned and combed. Roxburgh and Royle showed beyond all doubt that Sunn hemp was superior to jute, and this fact has since been confirmed. Dr. Watt states as his opinion, after carefully weighing the relative merits of Sunn hemp and jute, "it is impossible to urge too strongly the claims of this much neglected fiber." London brokers state that the only difficulty in pushing the trade in Sunn hemp is the inability to procure a uniform and large enough supply. If encouragement were given to the industry in Southern India, it is confidently anticipated that the foundation would soon be laid for a textile industry that would bear creditable comparison with the jute trade of Bengal.

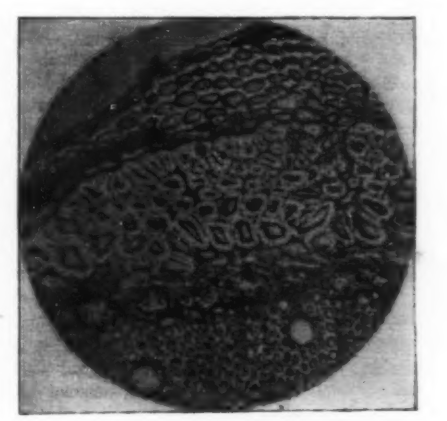


FIG. 5.—SUNN HEMP (CROTALARIA JUNCEA).

Section through stem. The uppermost tissue is the cortical parenchyma; next below is the bast region with fiber cells; lastly, comes the prosenchyma (woody tissue) with two large pitted vessels. Between the bast region and the wood is the cambium region. × 150.

Remarks.—The fiber bundles consist of 20 to 50 cells, not easily divided. Each cell is 3 to 5 mm. long, with the ends tapering abruptly; polygonal in transverse section with a small cavity. The wall of the cell shows well marked concentric rings.

Sida Hemp (Sida rhombifolia).—A very variable plant, widely distributed in tropical countries, with yellow or white flowers. It yields an excellent fiber, said to be better than jute, but, unlike jute, capable of cultivation over immense tracts of country. Sida fiber, from Queensland, exhibited at the Colonial and Indian Exhibition of 1886, gave great promise. Its superiority to jute was shown in the "uniformity, firmness, and divisibility of the fiber bundles, and in the softness and color of the raw fiber; it had also great capacity for bleaching." In regard to its future in India, Dr. Watt states, "no fiber of modern times affords better hopes of success than Sida."

Remarks.—The fiber bundles are similar to jute in all structural points. The filament is 1·5 to 2 mm. long, hardly distinguishable from jute.

JUTE.

Jute (Corchorus capsularis).—The jute trade of India is of the annual value of £10,000,000 sterling. There are about 2,000,000 acres under cultivation. The plants yielding jute are of two species. The one now under consideration is an annual, about 2 to 5 feet high. The base of the leaves is prolonged into two curious tail-like appendages. The fruit is a globose capsule, not beaked. The seed is sown broadcast in March to June and the crop is gathered to the end of September. It therefore occupies the ground only for about three to four months. When the stems are ripe they are cut down and steeped in water for

several days, until the bark is rendered soft and loose. The fiber is taken off by hand, and after being thoroughly washed it is hung up in the sun to dry. The preparation is, therefore, very simple, and no machinery of any kind is necessary. The best qualities of jute are of a pale, clear color, with a silky luster, easily spun and comparatively strong. There are numerous commercial sorts varying in color, degree of fineness, and in luster. Those of bad color are chiefly used for gunny bags. To lessen the harsh and brittle character of jute it is subjected to a crushing process with oil and water which softens the fiber and prepares it for the spinning processes. Dundee has long held a supreme position as the seat of jute manufacture, but many factories have, of late years, been started in India. The class of goods manufactured is not, however, the same.

The chief defects of jute are—(1) The fiber will not bleach readily; and (2) fabrics manufactured from it are apt to rot, when exposed to damp. It is, however, extensively used in the manufacture of gunny bags, gunny cloths, rope, twine, carpets, rugs, and printed tapestry.

Remarks.—Jute fiber consists of the fiber bundles cleaned by retting and washing. Each bundle consists of 6 to 20 cells. The latter are firmly coherent in the bundle. The cells are of the normal fusiform type, from 1·5 to 3 mm. long. In section they are thick-walled and polygonal.

Calcutta Jute (Corchorus olitorius).—The plant yielding the jute chiefly produced in the neighborhood of Calcutta is very similar to the common jute; but the fruit is hornlike, instead of globular, and possessed of a distinct beak. It is cultivated in many parts of the world as a vegetable, under the name of the "Jew's mallow." As a fiber plant it is regarded as of less value than the previous species. The methods adopted for its cultivation and the extraction of the fiber are identical with those of common jute.

Chinese jute is in some cases derived from the same plant as Indian jute (Corchorus); but some fibers exported from China as jute are yielded by very different plants. It appears that "jute" pays an export duty of 2 mace per picul, while "hemp" is charged 3½ mace per picul. There is, therefore, an incentive to pass all fibers as jute instead of under their proper names. American jute is sometimes an abutilon fiber,

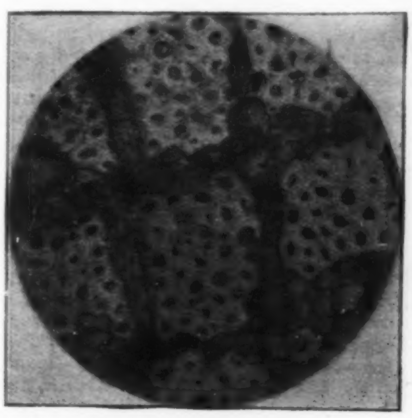


FIG. 6.—JUTE (CORCHORUS CAPSULARIS).

Section, highly magnified, through a portion of the bast region, showing the rectangular form of the fiber bundle, divided by plates of loose cellular tissue. × 300.

and sometimes identical with Indian jute (see Abutilon Avicennæ). A West African jute, from Lagos, is described in the Kew Bulletin, 1891, p. 15. This is known locally as Bolobolo fiber. It is yielded by Honckenya ficifolia. In 1889 the fiber was valued at £16 to £17 per ton.

HIBISCUS FIBERS.

Numerous species of Hibiscus, or mallows, are known to yield very serviceable fibers. The following are a few of the most notable:

Deccan Hemp (Hibiscus cannabinus).—This is also known as Kanaff and Ambari hemp. The plant is a slender herb; the flowers are yellow, with a crimson center. The fiber is said to be strong and durable, but so far is not known in commerce. Latterly it came into notice under the name of Kanaff, in the Caucasus (Kew Bulletin, 1891, pp. 204–206).

Okra (Hibiscus esculentus).—An annual herb, yielding a fruit used as a table vegetable known as okra, okro, or gombo. The stem contains a useful fiber with great strength and luster; it is adapted for making ropes, twine, and sacking.

Rozelle, or Red Sorelle (Hibiscus sabdariffa).—An annual shrub. The succulent calyx is edible, and is used for making cooling drinks. The fiber is strong and silky, and is known as Rozelle hemp.

Maholtine (Abutilon periplocifolium).—A shrubby plant with stems 8 to 10 feet long, common in tropical America, but also found in West Africa and the Nile valley. This is recommended as yielding a jute fiber of considerable merit. Specimens sent to Kew from Trinidad, in 1889, were valued at £17 per ton. An account of the Maholtine as a new fiber plant is given by Mr. J. H. Hart, F.L.S., in the Agricultural Record (Trinidad), vol. i, p. 217.

Ban-ochra (Urena lobata).—A very variable plant, widely distributed in the tropics. In India, the easily extractable fiber is considered suitable for the manufacture of sacking and twine, and a fair substitute for flax. The "Toja" fiber, of West Africa, is yielded by this plant. Samples sent to Kew, in 1889, were valued at £17 to £18 per ton.

Remarks.—The fiber bundles are indistinguishable from characteristic Hibiscus fiber. The filaments or cells are short, scarcely more than 1·5 to 2 mm. long.

Indian Mallow Hemp (Abutilon Avicennæ).—This is also known as China jute and American jute. The plant is a shrubby mallow, with yellow flowers. The fiber is said to be superior to Indian jute. An account of the plant, giving particulars respecting the cultivation and extraction of the fiber in China, is given in the Kew Bulletin, 1891, pp. 255–256.

Of plants belonging to the leguminous order we have so far only mentioned the Sunn hemp (Crotolaria juncea). The following also produce useful fiber.

Dhunchi Hemp (Sesbania aculeata).—This is of interest from the fact that the plant will grow in swampy situations. The stems are produced to the height of several feet. Royle states: "The bark yields a very excellent fiber for common cord and twine purposes, much superior in strength and durability to jute." From the pith of the twigs very singular and ornamental mats are also made in Assam.

Ko Hemp (Pueraria thunbergiana).—A trailing vine, producing flowers like a wistaria, long known in China and Japan, yields a very interesting fiber. This is obtained from the succulent green stems, and is used, but less than formerly, for summer clothing. It is said to be more durable than China grass cloth.

Malu Fiber (Bauhinia Vahlii).—The plant yielding Malu fiber is one of the most extensive climbers of the Indian and Ceylon forests. It is most abundant in warm, moist situations. The fiber is universally used by the natives of India. Dr. Watt states: "It is one of the few vegetable fibers that will stand to be dyed, bleached, and worked up along with wool."

INVESTIGATION OF BOVINE TUBERCULOSIS, WITH SPECIAL REFERENCE TO ITS EXISTENCE IN IOWA.*

THE following may be said to cover a portion of the ground that has been practically cleared from doubt:

(1) Tuberculosis of the lower animals is identical with human consumption.

(2) It is an infectious disease.

(3) The disease may be transmitted from man to the lower animals and from the lower animals to man.

(4) Tuberculosis causes more deaths in the human family than any other disease.

(5) Cows are especially susceptible to the disease, and are extensively affected by it.

(6) Milk from tuberculous cows may convey disease to the consumer.

(7) Milk from tuberculous cows having non-affected udders may convey the disease.

(8) The flesh of tuberculous animals may convey the disease.

(9) A large proportion of the cases cannot be recognized by clinical examination.

(10) No other test yet discovered than that afforded by tuberculin can detect any considerable proportion of cases in the living subject, and this test is practically infallible.

(11) Injections of tuberculin cannot produce tuberculosis, nor are the results harmful.

METHOD OF APPLYING THE TEST.

For the benefit of those not familiar with the methods of making the test, a word of explanation will be in place.

First.—The temperature of every individual in the herd to be tested is carefully taken and recorded at intervals of two hours during the day preceding the test. The average of these readings will give a pretty accurate test of the individual temperature of the several animals, which is recorded as the normal, with which any variations are to be compared. Before midnight of the day on which the trial temperatures were taken, the injection of lymph is made. This consists in injecting beneath the skin, with an ordinary hypodermic syringe, two cubic centimeters of tuberculin for every thousand pounds live weight of animal. The result to be expected is a more or less well marked rise in temperature shown by all individuals affected with tuberculosis. If the animal is free from the disease, no change of temperature will result. The rise in temperature will usually begin to manifest itself in from twelve to fifteen hours after the injection is made. From four to six hours later, the temperature in those showing reaction begins to decline and gradually reaches the normal. It is upon this variation in temperature alone that reliance is placed for determining the presence of the disease. Every possible precaution should be observed, that the conditions may be the same under which the temperature was taken, before and after the injection. Varying conditions tend to slight modification of temperature; hence the necessity for the greatest precaution, that only the change resulting from the action of the tuberculin may be shown.

If a change of one and a half or two degrees occurs, this is sufficient evidence on which to condemn the animal. A rise of four or five degrees is not unfrequently noted. There is no well authenticated evidence that these marked differences in rise of temperature shown correspond to like difference in the severity of attack.

RELIABILITY OF THE TEST.

With this feature of the subject we are especially interested. If the results obtained should not show a fair degree of uniformity under like conditions, then the test may be discarded as useless. If the test proves a means of condemning healthy animals, it is a harmful and dangerous experiment and should be discarded at once. If diseased ones fail to respond to the test, then it is to be regarded as a means of concealing rather than pointing out real dangers, and is worse than useless. With these thoughts before us, the work has been done with such attention to details as would insure a fair and impartial trial.

The conditions under which we have been obliged to work have not always been such as to allow all the privileges we could have wished for, in order to obtain the fullest results. It has not always been possible to secure for slaughter all the animals showing reaction. And as a matter of course we have not had the opportunity of performing autopsies on any considerable number of those that failed to show any reaction. These are regarded as healthy and are not usually disposed of in a way to afford opportunities for post mortem. Out of eighty post mortems made on animals showing reaction, not a single case failed to give evidence of tuberculosis. And in no case where an opportunity was afforded to examine the carcass of one failing to show reaction was the disease found to exist. In other words, the test has not failed in a single instance in our experience. Occasional failures have been noted by other experimenters. Whether this was due to lack of attention to details in the work, to want of searching methods in examining the cadaver, or to actual failure in the essential features of the test, we are not prepared to say. But it would not be a matter for surprise if there should be some contradictory results reported, owing to the many inexperienced hands into which the test has fallen. Our experience with the test, however, tallies so closely with the results obtained at other United States experiment stations, as well as scientific institutions throughout the world, that it may be said there is practically no disagreement among the workers in this field of investigation, as to the uniformity of the results. It may not be said of any drug in the pharmacopœia that it is infallible in its action; that it was never known to produce other than its generally recognized effects, and that these invariably followed the administration. But this by no means breaks the law of uniformity or reverses the rule of action.

The New Jersey experiment station in its bulletin, after detailing experiments made, summarizes its conclusions by saying, "Every case of undoubted reaction proved to be undoubtedly tuberculous."

The Wisconsin station, where careful tests have been made, publishes the results in bulletin form and gives expression to the following: "We have then in this agent a means of detecting the disease if we desire. The use of this agent is to be recommended."

Dr. Law, in a bulletin issued from the Cornell University Station, speaks of tuberculin as possessing "The highest value as a test of tuberculosis in animals." He further says in the same bulletin, "This has now been employed on thousands of cows, and those who have used it most value it most highly, whereas many who at first reported reactions in non-tuberculous animals are now acknowledging with Nocard that the fault has been mainly their own, for small tubercles were present, but were overlooked through their failure to examine the bones and other organs."

The same observations have been made by workers in the Maine Agricultural College Experiment Station. In the published reports of that institution we read, "With suitable instruments and professional skill it is comparatively easy for one man to examine a herd of fifty animals in less than twenty-four hours and detect every case of tuberculosis that may exist there."

The Massachusetts Station, after a long and unsatisfactory attempt to rid the college herd of tuberculosis by the weeding out process, decided to apply the tuberculin test. The bulletin of the station, in speaking of the effort to free the herd from this disease without the application of the test, says, "That in all probability we should never have been able to accomplish this is shown by a study of the records of the tuberculin test." Both those that reacted and those that did not were slaughtered, and the accuracy of the test fully demonstrated.

The North Dakota Experiment Station, through its bulletin, says, "We have taken pains to hold post mortems on all animals which have been tested up to date which yielded to the test, and in every one we have been able to demonstrate the presence of tuberculosis."

The conclusions of the Bureau of Animal Industry are thus summarized: "The number of instances in which the conditions indicated by the results of the injection do not conform to the conclusions founded on post mortem examination is so many times less the number of errors from all other methods used to diagnose tuberculosis, and there are so many cases of tuberculosis which could not possibly be detected by any other method, that even they who are least inclined to favor the use of tuberculin cannot fail to recognize its importance."

Our own station has had similar experience in dealing with the disease at home. No other means employed ever enabled us to free the college dairy herd from the disease. In every instance where post mortem proofs have been added to the findings of the tuberculin test they have coincided. It is not necessary to multiply at length quotations from independent experimenters. They are to one and the same effect. But we have thought it worth while to present a very little of the mountain of evidence in support of this test to offset the reiterations of the objector. I have cited the most unbiased and trustworthy evidence: the observations of men employed by the government who have no occasion to become swift witnesses in support of any theory or any practice. Investigations carried on by the station authorities of Minnesota, Virginia and Arizona, the sanitary board of the Dominion of Canada, and many other government stations and scientific bodies throughout the world, might be drawn upon for added evidence to the proofs already furnished.

EXPERIMENTS IN FEEDING THE MILK OF TUBERCULOUS COWS.

The use of milk on experiment animals for the purpose of artificially inducing the disease in otherwise healthy individuals is a practical way of putting to the test some of the theories as to sources of danger. If the milk from tuberculous cows, either taken in the ordinary way or injected directly into the circulation, can induce tuberculosis, the fact becomes one of no ordinary moment. The significance of the experiment has a twofold importance.

First.—It enables us to account for many cases of the disease in young cattle. It has been shown by repeated observations that congenital infection is rare. However, calves but a few months old are frequently found to be infected.

Second.—If milk from tuberculous cows possesses infectious properties, the health and safety of the human family becomes the important part of the question. If feeding the milk to lower animals under ordinary conditions will induce the disease, there is no avoiding the conclusion that it can be induced in the human family under the same conditions. This

* Abstracts from Bulletin No. 29, Iowa Agricultural College Experiment Station, Ames, Iowa.

experiment has been repeated with sufficient frequency and under conditions to prove the certainty of results beyond question. If milk is contaminated with the bacilli of tuberculosis, it will convey the disease. But under what conditions will the milk be so contaminated, is a question for separate solution. It has been vehemently claimed that only milk from cows with udders in which the disease was localized was to be regarded as in any sense dangerous.

An exhaustive series of experiments was undertaken by the trustees of the Massachusetts Society for the Promotion of Agriculture, with a view of gaining light on this question. One of the experiments consisted in feeding twenty-one healthy calves on milk from tuberculous cows. At the conclusion of their experiment they report, "Of these twenty-one animals, eight, or over thirty-three per cent., were shown to be tuberculous. That the cows from which the milk for these feeding experiments was derived were free from tuberculosis of the udder is shown by the following table (table omitted) of their history and the results of the post mortem examination." They draw the following conclusions:

"The possibility of milk from tuberculous udders containing the infectious elements is undeniable."

"With the evidence here presented, it is equally undeniable that milk from diseased cows with no appreciable lesion of the udder may, and not unfrequently does, contain the bacilli of the disease."

Dr. McKenzie reports that in cases where there were no lesions of the udder, but where tubercular deposits were found in other parts of the body, the milk in forty per cent. of the cases proved to be infectious.

This is in accord with the best evidence on this subject, and especially does the extensive scientific work of Bang, of Copenhagen, coincide with these results.

Our station made experiments on three calves from tuberculous mothers. Two were allowed to take the milk from the mothers. These cows were but slightly affected, the udders to all appearances being free from disease, and no bacilli were detected in the milk when examined under the microscope. Both of these calves developed tuberculosis. A third calf from a tuberculous mother was not allowed to take the mother's milk, but was taken as soon as born and kept on the milk of a cow that had been tested and found to be healthy. This calf never showed reaction when tested with tuberculin. It was slaughtered at the age of three months, and thorough examination failed to detect any sign of disease.

This experiment tends to show that calves from tuberculous mothers are not necessarily tuberculous at birth, but that infection will take place when the udders are healthy and when there is no external evidence of disease.

HOW THE INFECTION IS EXTENDED.

A living vegetable organism, the bacillus tuberculosis, is the reproductive agent which gives rise to the disease. When this germ finds lodgment in suitable tissues, and is uninterrupted by any antiseptic agent, or opposing force, it tends to multiply with a certain degree of rapidity, and the result in the affected tissue is the deposit of tubercle. Any organ of the body may be assailed, though lymphatic and other glandular tissue, the lungs, liver and spleen are parts particularly prone to be the seat of disease. Any animal affected with the disease becomes a center of infection from which the disease may spread. Its distribution is never rapid, but a single case in a herd is certain to be followed by others in the course of time if unrestricted cohabitation is allowed. The bacilli are coughed up or expelled from the body through other channels. These may be at once conveyed to the body of a susceptible animal, or they may lie in a dried and dormant condition for months and be revived into activity when implanted in a suitable soil. Every individual going out from an affected herd becomes a menace to the animals with which it is brought in contact. Doubtless the sale of breeding stock has had more to do with the general distribution of the disease than any other one agency. A general indictment cannot be entered against the breeding stock of the State, but many of our breeders can testify to the trouble they have experienced in their endeavor to free their herds from the scourge.

If an infected individual is brought into a herd of perfectly healthy animals, it becomes a menace to the health of that herd, no matter what the conditions are under which the cattle are kept, so long as they cohabit in an unrestricted way. Let no man flatter himself that his herd is safe in the presence of a single case of tuberculosis, no matter what the extent of acres over which they may range. True, these favorable conditions will lessen the chances of infection, but they cannot remove them. Several instances have come under our observation where badly affected animals came from the best kept breeding herds in the State.

WHAT ARE THE SYMPTOMS OF THE DISEASE?

This is one of the questions most frequently asked by the farmer. It is a difficult question to answer, because of the extent of detail involved in making a full statement of the case. From what has been previously said in these pages, it will be understood that almost any organ of the body may be the seat of disease. The symptoms will be correspondingly various. The pulmonary type, or that form of the disease in which the lungs are extensively affected, may be said to be the typical form. In nearly all cases where the disease is allowed to run its course, the evidence of lung affection will become apparent before death relieves the animal. This form of the disease is attended with difficult respiration, high temperature, frequent and feeble pulse, painful cough, failure of milk, emaciation, diarrhœa and finally death. Occasionally the first symptoms may be severe lameness from tubercular deposit in the articulations. Swelling and abscesses about the throat and the udder of cows are not unfrequent manifestations. When non-vital organs are the first seat of the disease, the animal may continue in a fair state of general health for months, and even years. Doubtless there are occasional cases of final permanent recovery. The disease in nearly all cases assumes a chronic type, which is misleading to the owner. But it must be accepted at once and for all that it is impossible to detect any considerable proportion of the cases at any given time, by the most searching physical examination of the expert. If it is the fixed purpose of the owner to find the real extent of the infection in a diseased herd, he must have recourse to slaughter, or apply the tuberculin test.

RELATION OF MEAT AND MILK SUPPLY TO PUBLIC HEALTH.

That the mortality in the human family from tuberculosis exceeds the death roll from all other infectious diseases put together, is a generally admitted fact. Statistics place the death rate from this cause as high as fourteen per cent. At some of our Indian agencies where the habit of eating uncooked meat is a general one, the mortality statistics show that fifty per cent. of the deaths is due to tuberculosis. It is a very difficult matter to determine approximately how much of the mortality from human consumption is to be attributed directly to infection from the lower animals. The causes in most of the cases are so hidden in obscurity that a definite explanation is impossible. But there is abundance of positive proof and still more collateral evidence to show that the food supply derived from the animal kingdom is no small factor in the distribution of the disease.

There are few experimenters, who have been close observers of these phenomena, who cannot cite cases that point at least in the direction of these conclusions.

One case came under our observation, where five young people between the ages of twenty and thirty years died of consumption, in one family, during a period of two years. Not a trace of the disease had ever been known in the family of either the father or mother of the victims. On the farm where the deaths occurred we found seventeen cases of tuberculosis in the herd of cattle, and others had died before the investigation was made.

Another bit of history in connection with a diseased herd that was under test is worthy of mention. A mother and child died; the mother from undoubted consumption, the child from intestinal trouble highly suggestive of the same disease. The cow that had supplied milk to the mother and child was tested and found to be tuberculous. Post mortem examination of the cow revealed a badly tuberculous condition of the udder. Similar observations on the part of other station workers and practicing physicians have been made so frequently that the conclusion is unavoidable that to some extent to our meat supply, and in a much larger way to our milk supply, can be traced many of the cases of tuberculosis in the human family.

HOW CAN HEALTHY HERDS BE SECURED, AND HOW CAN THEY BE KEPT FREE FROM DISEASE?

This is the practical question toward which all the others tend. It is of little consequence to know that disease exists unless that knowledge can be made to aid us in averting the evils we have found. The means by which total extermination of the disease can be accomplished do not seem to be in sight. So long as there remain cases of consumption in the human family, there remains the possibility of occasional reinfection of bovines. But the probabilities of infection from this source are remote, and should not be taken as arguments against any restrictive measures that might be adopted.

While absolute extermination of the disease at once may not be practical, we believe it to be entirely feasible to so far restrict its dangers as to render them of slight consequence. The State has already, with small expense, eradicated the disease in a considerable number of dairy herds. And what is of more value to the public at large than freeing these herds from disease, it has demonstrated the possibility and the practicability of the plan, and has done much to educate the people as to the sources of danger. The result is that many owners of herds have voluntarily, and at their own expense, had the tuberculin test applied, and the diseased animals destroyed. The work the State has done is in this way being supplemented, and the practice of testing dairy cows is likely have a very large increase in the future, without the aid of compulsory measures. Once the herd is free from disease, it can readily be kept in this condition by exercising due precaution in the introduction of fresh stock. Dairymen who have had unfortunate experience with the disease have adopted the practice of admitting none but tested cows to their purified herds. This practice, if uniformly adopted, would very soon render the dairy herds of Iowa free from tuberculosis. If, in addition to these precautions, similar vigilance were exercised over the introduction of breeding stock to the herds, the chief sources of infection could thus be shut off. If restrictive measures of this kind were applied to these two classes of cattle, practically all the cases of tuberculosis in the State would soon be found, and its ravages reduced to the minimum. The measures adopted in a few score of dairy herds in the State, if applied to the remainder, would go very far toward eradication. It is possible to reach most important practical results without the expenditure of large sums of money or the sacrifice of important interests.

All animals suffering from the disease in any of its stages should be at once removed from contact with other cattle. It is our judgment that any plan which contemplates keeping tuberculous animals on the farm, and attempting to avert danger by segregation and other like precautionary methods, will defeat its own ends. The less the number of possible sources of infection in the country, the more successful will be the efforts at eradication. Buildings where tuberculous animals have been confined are to be regarded as infected, and no healthy animal should be assigned quarters in such inclosure till thoroughly disinfected.

It is true, a single test may not in every instance free the entire herd. After-infection may take place. It would be wise in those cases where a number of badly affected animals have existed to take the precaution of applying additional tests some months after the first. All this involves care, the expenditure of a certain amount of money, and the occasional loss of an animal. But the animal already suffering from an infectious and highly fatal disease cannot be considered to possess any high value. The inconvenience and expense attending such precautions are small in comparison with the loss and risk involved in allowing the disease to run its natural course in the herd, and the sale of dangerous products for human consumption.

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